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FIRMS WITH A FUTURE

How would you measure progressiveness in an engineering firm or other organisation? Are there definable characteristics which distinguish the progressive from the backward? Two men who have recently carried out a survey of British industry are confident that there are 24 characteristics of this kind, and in putting their conclusions to the test they found that there were six firms in a sample of 50 who gained a score of 97 per cent. At the other end of the scale the six least progressive firms scored only 14 per cent.

Although the authors, Professor C. F. Carter and Professor B. R. Williams, are economists it is a pleasant surprise to find that only two of the 24 characteristics relate directly to the sort of factors which a company accountant would fasten on. They refer to " a consciousness of costs and profits in the research and development departments (if any)," and to " identifying the outcome of investment decisions "—both revealing the long-term approach. The more progressive firms scrutinise more thoroughly the economic justification both of new projects and of those which have been tentatively investigated. A really go-ahead manager will no doubt take up the challenge that " cost-consciousness, in the sense of economising in the use of scarce scientific and technical staff, was not well developed, even in the progressive firms."

Nearly all of the other 22 characteristics refer to the human element or to the flow of knowledge and ideas—which, after all, is a vital aspect of the human element. At the head of the list of twenty-four comes " high quality of incoming communication." The progressive firm takes technical literature of a higher quality and it has better contacts with scientists and technologists outside. Backward firms usually confine their reading to the lower qualities of trade journal, and they rarely have contact with outsiders of a wide range of vision. Thus they may not hear of an idea for several years after it is first made known. A dynamic approach usually brings in the second characteristic: " a deliberate survey of potential ideas." New ideas from outside and from within the firm are regularly surveyed. At the other extreme there is the self-satisfied parochial firm, protected from new ideas by its own complacency. In between is the " adoptive " firm, which is open to new ideas if they are presented in the developed form.

The third characteristic is one that we, as technical journalists, have often observed—" a willingness to share knowledge." There is, perhaps, no more effective form of publicity and good public relations in the engineering world than the desire and readiness to discuss the most up-to-date technical details with competitors and friends. Although, of course, every self-respecting firm has projects which it must keep in the dark for a while, beware of the firm which is wholly secretive. It probably has the least to hide.

The authors of the survey report that progressive firms " were astonishingly ready to throw open their factories to visits by competitors, though we gather that their more backward competitors rarely take advantage of this." A similar attitude is revealed in the fourth and fifth characteristics: " a willingness to take new knowledge on licence and to enter joint ventures," and " a readiness to look outside the firm "—which means that the technically progressive firms look outside themselves for their standards of performance. The sixth characteristic—" effective internal communication and co-ordination "—is apparent in teamwork by departments when new developments are being planned, in a clear understanding of responsibility, authority, and the objectives of the company, and in the fact that projects are not held up by differences in outlook.

The group of characteristics relating to the human element will strike a sympathetic chord in everyone with responsibilities in industry. They are: " a sound policy of recruitment for management, an ability to attract talented people, a willingness to arrange for the effective training of staff, the use of management techniques, high quality in the chief executives, adequate provision for intermediate managers, good quality in intermediate management, an ability to bring the best out of managers, the use of scientists and technologists on the board of directors, and a readiness to look ahead."

Two of the other characteristics are particularly worth mentioning—an effective selling policy, and a good technical service to customers. The characteristics have been formulated after a five-year inquiry into the state of technical progress in Britain. They have been published by the Oxford University Press on behalf of the Science and Industry Committee—appointed by the Royal Society of Arts, the British Association and the Nuffield Foundation. A two-day conference—one day in London on June 27 and one day in Leeds on July 5—is being arranged in order to discuss the report. There will certainly be discussions, too, in many boardrooms up and down the country.

Industry and Technical Progress: Factors Governing the Speed of Application of Science. By C. F. Carter and B. R. Williams. Oxford University Press, Amen House, Warwick-square, London, E.C.4. (25*s.*)

Plain Words

Lord Tedder said a few plain words last week-end about the future of the Royal Air Force: "Take my word for it; there are going to be aeroplanes and military aeroplanes, too, as far ahead as we can see. The idea that we are all going to sit in dug-outs and press buttons is just fantasy."

Two sentences in the Government's White Paper on Defence Policy no doubt fostered the impression which Lord Tedder is at pains to correct: "Fighter aircraft will in due course be replaced by a ground-to-air guided missile system" . . . "The Government have decided not to go on with the development of a supersonic manned bomber . . . the R.A.F. are unlikely to have a requirement for fighter aircraft of types more advanced than the supersonic P1, and work on such projects will stop."

Whatever may be the ultimate contribution of missiles to the defence of this country, some pertinent questions remain. Does the abandonment of specific supersonic projects mean that a halt has been called to high-speed research and development of aircraft? Is Great Britain to drop out of the race for optimum performance? Has the curtain been dropped on aeronautical progress?

Forty or fifty years ago outstanding progress could be achieved by a man and boy in a shed on the edge of a 40-acre field. Progress to-day needs at the very least a significant proportion of the resources of a great industrial company, and this is a burden which cannot long be carried without Government support. In aviation, progress and speed are almost synonymous, whatever the requirements for consolidation in respect of efficiency, economy and safety. Only 12 years ago the sound barrier seemed so final an obstacle to the increase of speed of manned aircraft that the Government of the day decreed that it must be attacked by missiles not men. Yet to-day the Under-Secretary for Air breaks the sound barrier as passenger in a twin-seat Hunter and affirms that there is nothing in it and that he never had as smooth a ride piloting aircraft of less than half the speed.

This is not the time to rest on our laurels, bright though they are; with titanium alloys in prospect for the structure, and, for the power plant, the ram jet available and nuclear power in prospect. The quest for higher speeds of manned aircraft must be continued. The R.A.F. needs at least a supersonic wing so that it may always have the know-how to fly faster than any possible foe, since all the possible applications cannot yet be foreseen in detail. Britain still holds all the world speed records—by land, sea and air. We must consolidate our position.

NEW LEASE OF LIFE FOR AN OLD RAILWAY WORKS

One of the least-known features of the narrow-gauge Festiniog Railway in North Wales is its fully-equipped and self-contained engineering works at Boston Lodge, about a mile from Portmadoc, the headquarters and lower terminus of the line. In its hey-day Boston Lodge Works was capable not only of doing all the routine maintenance on the line, its rolling stock and its locomotives, but also of building new equipment, including goods and passenger vehicles and even locomotives, a feature which, if not unique, was certainly most unusual for a 14-mile line of 1 ft. 11½ in. gauge. Considerable outside contract work was also undertaken for the quarries and shipbuilding yards in the area served by the railway.

When the present management took over in 1954 they found the works, like the permanent way, rolling stock and locomotives, in a sorry state after eight years of idleness and neglect.* Repair of some of the most useful parts of the works has proceeded concurrently with the general rehabilitation of the line, and to-day, though much still remains to be done, a large part of Boston Lodge Works is functioning again.

The date of establishment of the works cannot be stated with certainty; research which might establish this date and many others of interest in the history of the line has yet to be undertaken. But there is reason for believing that part of the works on the north-east side, around what is now known as the Top Yard, was there about 1836, when the railway was opened. Some of the buildings in this part of the works were certainly in existence in 1848, for a plan of that date shows them as they are at present, and this plan is concerned with alterations to the then existing works.

The first buildings to be brought into use were the iron and brass foundries, smithy and old carpenters' shop. All these could obviously play a useful part in the running of the line (or even in its construction), for although the railway had no locomotives until 1863, rolling stock had to be built and maintained, as well as the permanent way itself. Little or no machining facilities could have existed at first; in fact the need for them would be very small before the locomotives were acquired. One or two machines of a simple type would suffice, and they may well have been provided from an early date, though there is nothing to show that they were. The first locomotives, "The Prince" and "The Princess," both 0-4-0 saddle tank engines built by George England, came into service in 1863. Other locomotives followed, and by 1865 a regular passenger service was in operation.

Such developments would call for increased workshop facilities, and these were provided, though again there is uncertainty about the date. It is known that the original machine shop was at the back of the existing locomotive sheds, and that the motive power was supplied by a steam engine and a vertical boiler; the latter was also used to assist in steam raising in the locomotives. The machines in this shop continued in use after the present machine shop was built, being moved there at some time between the two World Wars.

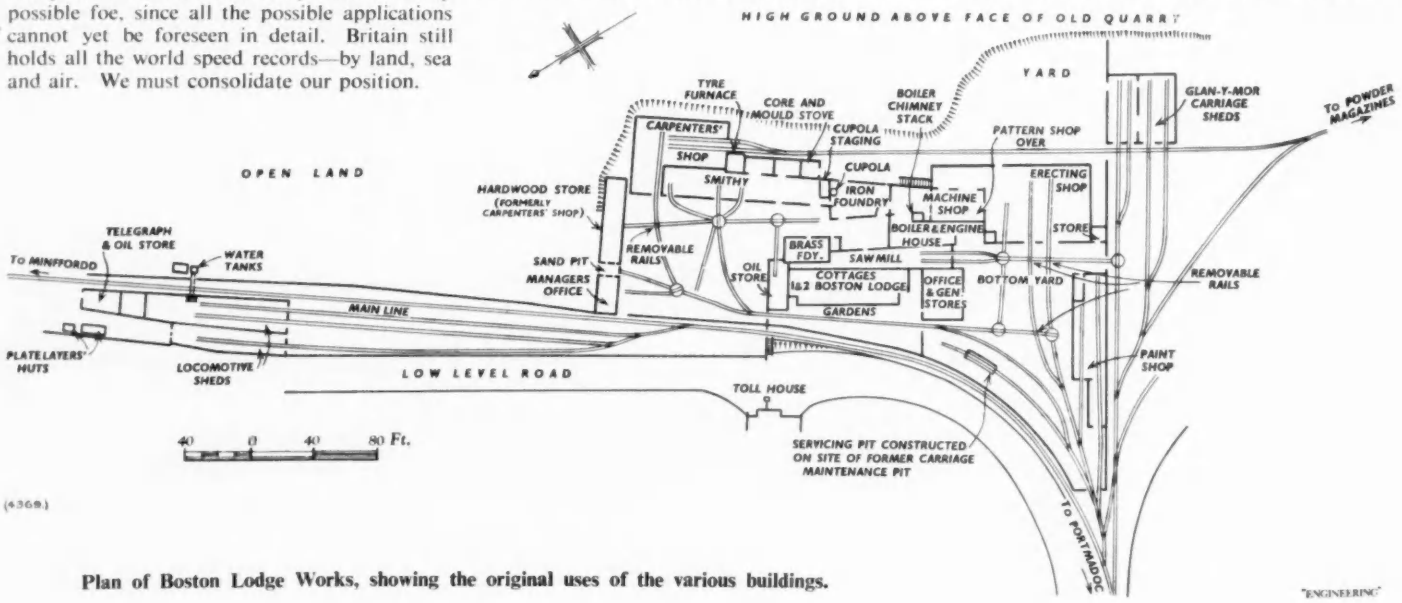
PREPARING TO BUILD LOCOMOTIVES

The original locomotives were successful, but in a short time it became apparent that something more powerful would be needed to cope with increased traffic. This need was met by the Fairlie double-boiler articulated locomotive, the first of which, "Little Wonder," was built by George England and put to use in 1869. The phenomenal success of this locomotive led to the building of others, and by the late 1870's Boston Lodge was being prepared for its greatest achievement, the building of two Fairlie doubles, both of which still exist. One, originally "Livingston Thompson" and now named "Taliesin," was re-built at Boston Lodge in 1956 and is now in service; the other, "Merddin Emrys," awaits overhaul. An erecting shop was put up in 1878 on the Bottom Yard site to deal with the Fairlies. The machine shop, which adjoins the erecting shop, may date from the same period, but there is evidence to suggest that it is older. It may have been built in the late 1860's, when the company were constructing a lot of rolling stock. At all events a machine shop would be essential to such work as locomotive building, and it was certainly there in 1878.

FINAL LAYOUT

Some re-arrangement of the works has taken place under the present management as a matter of expediency, but the layout as it was when the works was in full operation is easily traceable. The plan reproduced herewith names the original purposes of the buildings. The locomotive

* The re-organisation of the company and the start of the work of re-opening the line are described in ENGINEERING, June 1, 1956, pages 418-9.



Plan of Boston Lodge Works, showing the original uses of the various buildings.

sheds, a short distance to the north-east of the works, have three roads, and contain little of interest at present.

The works proper occupies the site of the quarry which supplied the stone for building the embankment. A pedestrian gateway leading to the main line gives access to the Top Yard, and ranged round this yard are the manager's office, a timber store (formerly the carpenters' shop), the present carpenters' shop (*c.* 1875), smithy, iron and brass foundries (all three *c.* 1836), and an oil store. The brass foundry, which still has its single-crucible melting furnace, is used at present as a store for signal and telegraph equipment. The carpenters' shop, on the other hand, is being brought back into use for its original purpose, and wooden-bodied rolling stock is being repaired there.

It is the iron foundry and smithy which are the most interesting buildings at the Top Yard, for both contain some very old equipment, some of which, in the smithy, is still used. In the foundry the small two-tuyere cupola still stands, and the wooden swivel crane with its travelling crab is intact. The foundry is small, but it was versatile. Moulding was by hand, but there is ample evidence that greensand, drysand and loam moulding were all practised; a drying stove outside the foundry is large enough to take a bogie loaded with cores or moulds. Much of the foundry's work must inevitably remain unidentified, but at least one cast-iron bridge, over the line at Tan-y-Bwlch, bears witness to the skill of the old moulders; it bears the legend "Boston Lodge 1854."

The smithy is a relatively large building, as might be expected. It has three old brick hearths and three of a more modern design, all blown by hand bellows, and also from the blower which supplied blast for the cupola. With the exception of a very small Massey steam hammer of unknown date, there is no power-driven machinery in the smithy at all. What little machinery there is, such as a $\frac{1}{2}$ in. diameter single-speed hand drilling machine, is normal smithy equipment. A more unusual item is a hand-operated slotting machine of $3\frac{3}{4}$ in. stroke. A coal-fired tyre furnace and a Tangye hydraulic wheel press, operated by hand pump, emphasise one of the purposes of the smithy—maintaining the hundreds of slate wagons in use on the line.

A pair of cottages and the former boiler and engine houses occupy, with the foundry, the approximate centre of the works, and divide the Top and Bottom Yards. It is in the latter part that most of the restoration work has been done so far, for the very good reason that it contains the equipment most useful for the rehabilitation of the line. Bordering this yard are an office and general stores, a sawmill, the old engine and boiler houses, the machine shop (with the pattern shop over it), erecting shop, and paint shop (used at present as a carriage shed). Behind the yard and quite separate from it, lie the carriage sheds on the site known as Glan-y-Mor.

POWER PLANT

At one time the works was driven by a steam engine, though of what type is uncertain. Legend has it that the engine was of the beam type made at Boston Lodge, which is by no means impossible, but proof is lacking. Some beam engine patterns still exist in the works, but they might have been used for casting outside orders. The boiler seating and chimney stack and the foundations of the engine remain, but the latter have been altered and cannot, in their present condition, be identified as belonging to any particular type of engine. A Tangye 40 h.p. single-cylinder horizontal oil engine took over the power duties in about 1925; this engine was scrapped after an accidental fire just before the second World War. Loss of engine power must have stopped the foundry, which has not worked since. Similarly, the sawmill would have come to a standstill when the engine stopped, even if it had not been closed earlier, which is quite possible. The sawmill machinery has been removed, but it is obvious that the mill was equipped to convert logs to boards, and at one time it did a large trade with the shipbuilding yards at Portmadoc.

This view of the Top Yard at Boston Lodge railway works shows the condition of some of the buildings brought about by eight years of neglect.

The railway was not very active after 1939, and what little power was needed in the machine shop was provided by a small Bollinder single-cylinder marine engine which is still there. This engine could also be belted to a generator for lighting purposes. During part of the second World War the works was used for war work, and a Crossley vertical single-cylinder hot bulb oil engine was installed at the end of the erecting shop. This engine, rated at 20/22 b.h.p. at 400 r.p.m., is still in use.

Next to the engine house is the machine shop. Part of this building has a second storey, occupied by the pattern shop; it is the only two-storey workshop at Boston Lodge. The pattern shop has only two machines, both lathes of unknown make. One is of $10\frac{3}{4}$ in. centres, with a bed 18 ft. long, and the other is a faceplate lathe capable of swinging 6 ft. Both take their drive from the machine shop below.

In the machine shop the equipment is orthodox and, for its time, adequate. Lathes predominate, as might be expected, and with the exception of a Butterworth 10 in. centre sliding, surfacing and screwcutting lathe, all

Repaired and in full use, the erecting shop already has two locomotive re-builds to its credit. The vehicles seen on the right are used as a works train, and include a concrete mixer, cement wagon and weed-killing tank.

Typical of the old equipment of the machine shop is this centre lathe. It is of unknown make but still serviceable.

are of unknown make and date. All the machines in the shop are belt driven from overhead line and counter shafting, most of the lathes having four-step cone pulleys. They include a gap-bed machine swinging 27 in., an 18 in. wheel lathe on slate foundations and a 20 in. screwcutting lathe taking 16 ft. between centres. A 2 in. capacity pillar drilling machine with power feed is the largest machine of its type in the works. Other machines include a 30 in. by 30 in. by 9 ft. planer, a 12 in. slotter and a screwing machine, all made by Kendall and Gent.

BOILERMAKING

A certain amount of machinery is installed in the erecting shop. This includes a pedestal grinder, a 1¼ in. pillar drilling machine and a Butterworth 15 in. screwcutting lathe taking 5 ft. between centres. A hydraulic wheel press is also installed in the erecting shop. There are no overhead cranes, but the shop has pits for locomotive maintenance work. Since the revival of the railway a 36 in. woodcutting circular saw, the only survival in the sawmill, has been moved into the erecting shop and belted to the main shafting. Mains electricity has been installed for lighting purposes, and a ¼ in. electric drill is now available.

It will be seen that Boston Lodge was well equipped for the work it had to do. Indeed, there is only one type of machinery which is now missing—boilermaking plant. Undoubtedly, boilers were made there, and it appears from the statements of old workpeople that this work was done in the smithy. Several items of equipment were scrapped from this department before the present management took over, including a machine which, from the verbal description, was clearly a hand-operated shear capable of quite heavy work. Some light bending rolls still exist near the locomotive sheds, and these were used for rolling smoke-box plates. No trace can now be found of heavier rolls such as would be necessary for boiler barrel and firebox bending, or of any sort of flanging press, but such items must have existed formerly.

ACCESS TO THE WORKS

At one time a tunnel under the main line connected the Bottom Yard with the road to Portmadoc, but this entrance has been filled in. A rail track enters the works through a gateway at the end of the embankment, and another track skirts the works to serve the former gunpowder magazines near the sea shore. By reversing from this track, vehicles can travel behind the works to the carpenters' shop. The layout of the tracks within the works can be seen on the plan, and no further explanation is needed.

Such is Boston Lodge to-day. As with the railway itself, much has been achieved, but still more remains to be done. It has been generally admitted that it would have been a tragedy if the Festiniog Railway had been allowed to pass into oblivion. It would have been equally unfortunate if Boston Lodge Works had been destroyed, for not only is it an integral part of the railway, but it is an almost perfect example of an engineering works of the Nineteenth Century. Fortunately, it is in good hands, and its necessary repair is not likely to interfere with its essential character any more in the future than it has done already.

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THE ROAD TO THE TOP

Last week, in our article "The Road to the Top" (page 674), reference was made to a recently published survey of management selection methods. The full title of the report is *Company Executive Development Schemes:* A survey in North-West England made by the British Institute of Management and the Manchester College of Technology. It is published by Management Publications, Limited, price 10*s.* 6*d.*

Weekly Survey

Cover Picture: *The upper portions of the two roll housings of a rolling mill embody the screw-down gear which regulates the height of the upper roll in a two-high mill. Our illustration shows a heavy roll housing, weighing* 100 *tons, on its side in the machine shop. This enables the milling of the joint face to be carried out conveniently.*

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Green Light on China

The British decision to ease controls on trade with China has been welcomed in the engineering industries. Exports are expected to double to an annual rate of about £20 million. This is "a guess" by the Board of Trade, but the increase may initially be far greater and the eventual level will tend to be governed by the amount of goods for which China can pay in acceptable currency. Restrictions are now the same as those on trade with the Soviet bloc countries. This means that motor vehicles, tractors, locomotives and rolling stock and some of the products of the machine tool, electrical machinery, instrument and other engineering industries can be exported. Welcoming the Government decision to go ahead without the United States and other members of the Paris China Committee, Mr. C. S. Garland, president of the National Union of Manufacturers, commented that it was "long overdue. It should open wide and profitable markets to British exports."

The American reaction has been surprisingly mild. The official expression of "disappointment" by the State Department has not been very widely echoed in the United States. Congress and the Press have generally welcomed the move. There are now indications that other members of the China Committee—among them France, Japan and Denmark—will follow Britain's example. In Peking, the Foreign Trade Ministry stated that China would want to buy machinery, precision instruments, high-grade steel, mining equipment and refinery plant. Last year's harvests were poor, however, and there has been a slowing down of mechanisation schemes.

The next step is to seek a revision of the embargo list on exports to Soviet countries. Some of the banned items are being exported by Czechslovakia and Eastern Germany to Western Europe and there is scope for a reduction of the list. Any further moves towards easier trade relations, wherever strategic considerations allow, will be welcomed by British engineering firms. The fact that they will now be able to deal with inquiries from the Chinese is a major step forward.

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Cheap Middle East Oil?

For the first time in the history of the oil industry the two Gulfs are not in step, and for the first time also prices of petroleum products are being quoted f.o.b. Persian Gulf. In the past the "Gulf" price has invariably been that quoted f.o.b. Gulf of Mexico. During the Suez crisis the pressure of demand from Western Europe caused the prices of Venezuelan and Texan oil to rise sharply by 20 to 30 cents a barrel while Middle East prices were held level. The re-opening of the canal was expected to lead fairly quickly to a return of the old practice of a unified oil market. The action of British Petroleum last week suggests that Middle East prices will rise, but not to the Persian Gulf level. The Shell Petroleum Company followed the lead given by B.P. Trading and raised its crude oil prices by 13 cents a barrel.

Present indications are that the American crude prices will fall, as over-production is developing both in Texas and Venezuela. From Britain's point of view, with so great an increase in the use of oil inevitable during the next decade, B.P.'s move could mean cheaper fuel and therefore an improvement, however slight, in the competitive position. It will be most interesting to watch the reactions of the large American companies. It is an accepted fact that Middle East oil is considerably cheaper to produce, and the oil industry's policy to keep world prices to the United States level was becoming increasingly difficult to defend. As Middle East production increases, and as methods of transport are lowered by the use of large tankers and new pipeline networks, western Europe should be provided with the cheapest oil in the world.

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Agricultural Machinery and the Common Market

Among the British industries at present studying the probable effects of the European Common Market are the agricultural machinery manufacturers. The Agricultural Engineers Association believes that the Common Market will result in increased trade though it is prepared for increased competition.

In the period from 1954 to 1956 when exports of agricultural machinery rose little, and exports of tractors showed a small decline, the figures for shipments to some European countries stand out in marked contrast. Tractor shipments to France doubled to over £3 million, as did those to Finland. Shipments to Western Germany reached £1·2 million from £540,000. These same countries have also imported steadily increasing quantities of agricultural machinery. Though exports to Iraq and Iran were comparatively low in 1956, the reported increase in the first two months of 1957 is encouraging, particularly in view of the increased German activity in the Middle East.

The Association conclude that the future is encouraging and believe that progress can be made not only in comparatively new markets but also in traditional markets such as Australia, which still leads the list of importers of both tractors and machinery from Britain. On this showing the agricultural machinery industry has less to fear than many from the effects of the Common Market.

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Boilers on Test

The development of the boiler industry has been affected by technical change in the past year or so and will be affected in the next decade probably more than that of any other section of the engineering industry. Sir Lionel Fraser, chairman of Babcock and Wilcox, made this quite clear when he said "These are times of change and of unique promise, and they call for special zeal and newness of approach to all problems." Like the cable makers, British boiler makers are basically confident they are in firm control of the technical world in which they move. Babcock's chairman said "we believe we are building on sound and firm foundations": yet profit margins are slight, costs are rising and the impact of foreign competition felt more keenly than at any time since the war. For companies such as Babcock's, who have some 40 per cent. of their business overseas, it is a major consideration which must not be allowed to retard research and development programmes but rather the reverse.

Makers of turbo-alternators, most of whom are now operating in association with other companies for the design and construction of nuclear power stations, are affected by similar considerations though in their case the impact of technical change is in a different direction—e.g., turbine design and the use of new metals—and on the whole less brutal. They too have experienced

rising costs and reduced profit margins. The Lancashire Dynamo Group, until recently headed by Lord Mills, report that "there will be no easy markets and no comfortable margins and it will not be easy to maintain the Group's trends of profits in the years ahead." This they interpret as a challenge and a spur to greater efficiency. Reporting earlier last month, Sir Claude Gibb, chairman of C. A. Parsons, commented on the competition likely to arise from Britain's entry into a European common market, which will force British industry and its workpeople to face the hard fact that without continuous factory re-equipping and the highest efficiency, many sections of industry will be forced into bankruptcy.

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Brighter Outlook for Cables

The annual reports of three manufacturers of electric wire and cable suggest that the troubles forecast by some other companies in the industry earlier this year may not after all materialise. The chairman of British Insulated Callender's Cables, Limited, Mr. W. H. McFadzean, commented that some uncertainty remained concerning the immediate future but expressed "every confidence" in the longer term prospects of the company: "we are engaged in an industry which inevitably must expand, for the increased use of electricity is a fundamental of all industrial development and progress and of raising the standards of living everywhere." Sir JohnDalton, chairman of W. T. Henley's Telegraph Works Company, gave the same impression of confidence in the future of the industry: "the excellent progress made in the atomic energy programme, electrification of the railways, shipbuilding and other contributions to the National wealth, indicate that the demand for our products should continue on an increasing scale." Both companies reported very large orders, and Henley's saw improved indications for the future.

There is no doubt that 1956 was a difficult year for the industry. Another leading company, London Electric Wire Company and Smiths, attributed a set back in profits to the fall in the orders from the motor, radio and domestic appliances industries. Stability in copper prices at a much reduced level which developed during the current year is likely to benefit the whole industry. B.I.C.C.'s chairman refused to take a view on the results for the current year, except to point out that orders were "up to our figures for the corresponding period last year." All three companies have expanded considerably and therefore look for an increased amount of business. Competition is likely to be keen, at home as well as in all overseas markets. Their confidence in the future is based on the benefits they are beginning to derive from expansion and modernisation schemes, and from their ability to compete technically anywhere.

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Motor Industry's Problems of Growth

No sooner had the motor industry's output of cars reached within 10 per cent. of the peak of its post-war performance than the Government raised the statutory deposit for hire purchase from one-fifth to one-third. This has produced angry criticism from the industry. Manufacturers may well wonder whether they are justified in the confidence they have shown in the future expansion of the demand for cars—to the tune of some £200 million of investment—if the Government are so determined to prevent them from achieving their targets. The magnitude of the setback of the past 18 months is to be seen in a comparison of to-day's performance—10 per cent. less than the peak 1955 level—with an anticipated level at least 10 per cent. greater.

The recent announcement by the British Motors Corporation that they were to enter the rolling stock manufacturing industry could be significant. If, as now seems likely, the home market for vehicles is to be restricted on a semi-permanent basis, investors in the motor vehicle industry are unlikely to get a very good return on their money, and the industry will find it increasingly difficult, therefore, to obtain the capital it needs to carry on its expansion. In the circumstances the only solution is to make those things the sale of which the Government are unlikely to restrict. B.M.C. chose rolling stock. Others may go for machine tools, or electrical machinery. Already most of the car manufacturers are producing 6 to 7 ton lorries. Ford now offer a six cylinder Diesel engine in their new Thames Trader range of trucks, taking one step further the car industry's invasion of the heavy vehicle builder's preserves. In seeking turnover from the railways, the B.M.C. follow A.C.V. and Leyland who have been there for years, and others in the heavy industry. We may yet see in the car industry, for a few years at any rate, something of the efforts now being made by the aircraft industry to move into other fields.

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Siting a Steel Mill

With the request last week from Scottish Members of Parliament to see the Prime Minister about the location of the proposed steel mill to be put down by Richard Thomas and Baldwins Limited, the battle of the site has got into its stride as a three cornered affair. So far as the Scots are concerned, the attraction of a steel unit in Scotland with sheet capacity is as a temptation to the motor vehicle industry to put up new capacity there—a temptation to which the Scots hope the industry would succumb. Despite some successes of recent years to diversify Scottish industry, the Scots are still sensitive to this problem. They remember with nostalgia too, that some of the early cars, such as the Argyll and the Arrol-Johnston, came from Scotland although they did not survive the early 1930's. The main argument which the Scots have to meet is the National Coal Board's insistence that there is insufficient coking coal north of the border to sustain a new steel unit of around 2 million tons a year capacity.

Welsh M.P's have also sent a deputation to the Prime Minister. Those responsible for recommending the siting of the new steel mill have examined nearly a dozen sites and the need for some eight square miles of land, 20 million gallons of water a day, good ore-handling installations at a nearby port and reasonable rail communications to the market all favour the Newport area. The rivalling claims of West Wales are mainly sociological. The gradual closing of the old hand mill provides a supply of labour which runs some risk of being left derelict by advances in technology. The strength of the West Wales case should not be underestimated however. There is very little unemployment in the Newport area and the siting of the mill in that locality may attract additional labour into an area which is already heavily dependent on steel. At the moment, however, the Newport area is the favourite among the likely starters.

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Liner Building

The announcement recently that the Cunard Steam-Ship Company have reserved a berth at John Brown's shipyard for a new liner for the North American service will be welcome news to the shipbuilding industry in view of the very small proportion of orders for new tonnage which consists of passenger and passenger-cargo liners. In view of the diversity of work involved, British shipyards are particularly well equipped for this type of work and it is frequently argued that their main competitive strength lies in this field rather than in the construction of large tankers and ore-carrying vessels. Yet order books at present include only eight major passenger liners totalling about 240,000 gross tons which is equivalent to about 3½ per cent. of total orders on hand. On a value basis, however, the percentage is probably about double this, the total cost of the eight liners being about £67·5 million compared with the total outstanding order book at the end of March, 1957, of £915 million.

The decision to build the new Cunarder follows the completion by John Brown of four 22,000 ton liners for the company's Canadian service, the last of which, the Sylvania, began acceptance trials last week. Details have not yet been announced of the new liner which is intended to replace the Britannic, built at Belfast in 1930. The latter is of 27,666 tons and it is expected that the new vessel will be of about the same size and will cost between £8 million and £10 million. The largest passenger ship at present on order is one of 45,000 gross tons for the Peninsular and Oriental Steam Navigation Company; the hull will be laid by Harland and Wolff, Belfast, in September this year. Two other large vessels on order are one of 40,000 gross tons for the Orient Line, to be built by Vickers-Armstrongs (Shipbuilders), and one of 38,000 gross tons for Union Castle to be built by Cammell Laird. Another Union Castle mailship, the Pendennis Castle of 29,000 gross tons, is under construction by Harland and Wolff.

It is thought that the new Cunarder may be the last liner to be ordered by the company until the Queen Mary is replaced.

Letters to the Editor

INFORMATION SCIENTISTS

SIR, With reference to your report of the Aslib Conference (ENGINEERING, May 31, page 693), and the rejection of the proposals for the professional organisation of information officers within Aslib, I should like to state that most of us who sponsored these proposals have felt for some time that a separate organisation, unified in purpose, was the better solution. Such an organisation should be prepared, of course, to collaborate with Aslib wherever possible. We are no longer concerned, however, to waste time arguing on the obvious fact that information work is a new special field of endeavour, distinct from librarianship, and forming the basis of a separate profession.

The field of information work is largely concerned with science and technology, and, to cut across difficulties concerning names involving ambiguities, such as information officer, documentalist, special librarian, and so on, I have previously suggested the term "information scientist"; I propose, therefore, that the new organisation should be called the "Institute of Information Scientists." To commence with, its main objects would be: first, to establish and extend the scope of information work and to promulgate high standards in such work, in the interests of industry in general, and of employers and employees; and, secondly, to establish recognised qualifications for information work, on a basis of suitable experience and, as soon as possible, of suitable instruction courses. We should look to Aslib to provide or promote such courses.

Such an Institute, I suggest, should

1. Non-graduate assistants in information departments (by Associate Membership);

2. The main body of information scientists, who are mostly graduates (by Membership); and

3. Senior personnel, who could acquire Fellowships by suitable evidence of advanced status and

Letters to the Editor (continued)

experience, or by submitting published work in a special branch, or by a thesis.

May I ask through your columns, therefore, that all who are engaged in information work and who are interested in these proposals should write to me now. Helpful criticisms of these initial suggestions will be welcome. The first aim is to form a small nucleus of experienced information scientists (in any subject field) who feel that they can devote some time and energy to the task of establishing an Institute. It will be essential, nevertheless, to form an early estimate of the total eventual support to be expected; hence this appeal to all concerned to notify me of their interest now.

Yours faithfully,

J. FARRADANE.

Torran, Crofton-road,
Orpington, Kent.
June 1, 1957.

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NOTATION IN STRESS ANALYSIS

SIR, The diversity between notations used in engineering, referred to in Mr. John Case's interesting letter on page 616 of ENGINEERING for May 17, may be an indication that present notations do not altogether fulfil all necessary requirements.

B.S. 1991 (Part I) 1954, also refers to chemical symbols and formulae that are in some respects more systematic and useful than those used in engineering and physics. A chemical formula not only represents a particular substance, but it indicates the components and their relative proportions, so that the chemist is able at any stage in his calculation to check the units and balance both sides of an equation. It is suggested that engineering symbols and formulae could be used similarly by choosing symbols for each quantity to represent also the theoretical dimensions, thus enabling the component parts of each formula to be easily verified and balanced in equations and in calculations. This method is quick, reliable and sometimes necessary.

Most of the symbols used in B.S. 1991 (Part I) are readily adaptable to dimensional formulae and it is necessary only to decide on a convenient system. Units of one dimension are conveniently represented by small letters and units of two dimensions by capital letters. Three dimensions may then be represented by a capital letter and a small suffix, e.g. Z_x = section modulus; and four dimensions by a capital letter and a capital suffix, e.g., I_X = moment of inertia. Non-dimensional quantities, such as ratios and numbers, may then be represented by Greek letters, as also can unit strain (Professor W. C. Unwin used λ), while actual or total strain would require a small letter.

It is only in recent years, and for no apparent reason, that a Greek letter has been used for stress, with the dimensions length^{-1} × mass × time^{-2} that are also the dimensions of the elastic modulii. In order to conform to the conventional notation it is suggested that " time " should be a negative dimension, so that stress could be represented by f_a, f_x, etc., or by F (general), and Young's modulus by E. Since time is measured in terms of the earth's angular velocity (dimension: time^{-1}), this convention would have a theoretical justification.

Considering, for example, the general formula for the deflection of a beam: $y = \frac{\beta W_X l^3}{E I_X}$ where W_X = the transverse load, l = the length, E = Young's modulus, I_X = the moment of inertia and β = a non-dimensional coefficient for the type of loading and end conditions, the left-hand side has one dimension and the right-hand side has (7 dimensions less 6 dimensions) one dimension.

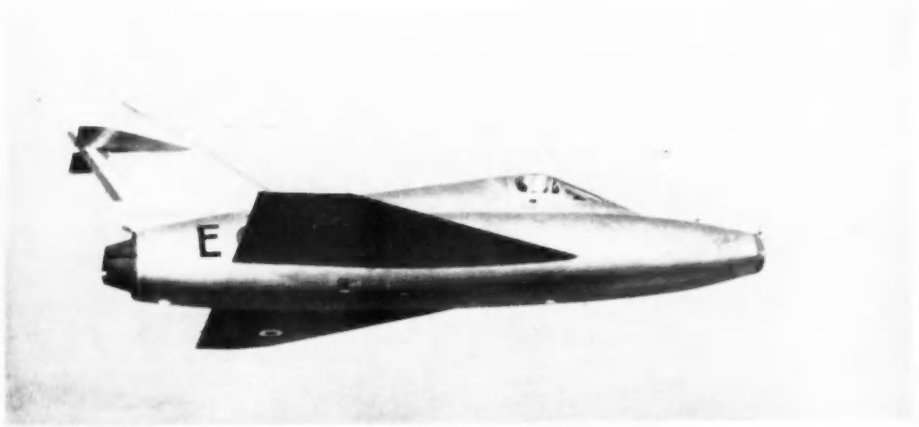
Yours faithfully,

A. N. PROCTER.

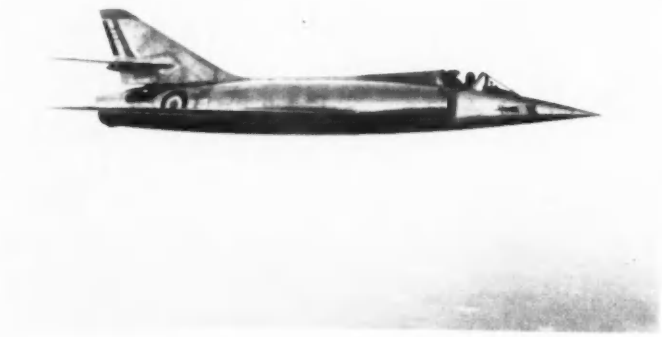
Nottingham.
May 31, 1957.

(Left) A Nord SS10 missile being launched from a Djinn helicopter. The missile is a short-range weapon propelled by a solid rocket.

(Below) The experimental Nord Gerfaut II is the fastest climber in the world. It is powered by a turbojet with afterburner. S.N.C.A.N.



(Above) The ultimate development of the Trident II interceptor will be a ground-to-air missile. Sud Aviation.



(Left) The supersonic swept-wing Etendard IV tactical support aircraft can operate from grass airfields. GAMD

THE FRENCH AIRCRAFT SCENE

(1) COMBAT AEROPLANES AND MISSILES

The French contribution to military aircraft development has, during the last few years, been concentrated upon the lightweight tactical aircraft that can be operated from restricted spaces without sacrificing high performance. Low-pressure tyres are widely used to allow operation from improvised runways—or even from grass; and in many cases a wide use of lightweight sandwich construction keeps down the airframe weight. One of the ways of attaining high performance at high altitude that has been favoured by French designers is the use of rocket engines to supplement turbojet power, providing very rapid climb to, and high acceleration at, operating height. At least three such "mixed power" interceptors are being developed; two were on view at the 22nd Salon International de l'Aéronautique which concluded last week in Paris—all using liquid-fuel rocket engines of the nitric acid-furaline type developed by la Société d'Étude de la Propulsion par Réaction, 37 Rue des Acacias, Paris 17.

MIXED-POWER FIGHTERS

First flown in April last year, the SE212 Durandal prototype single-seat delta-wing interceptor was designed and constructed by the Sud-Est constituent of Sud Aviation, 37 Boulevard de Montmorency, Paris 16. It can also serve as an attack bomber carrying external load. Powered by a SNECMA Atar G 9,700 lb. thrust turbojet with afterburning, and a SEPR rocket engine, slung under the fuselage, the Durandal is said to be a very fast climber and to be "largely supersonic in performance."

The prototype Mirage III delta-wing interceptor aircraft designed and constructed by Générale Aéronautique Marcel Dassault (GAMD), 78 Quai Carnot, Saint-Cloud, is a development of the "mixed power" Mirage I which, with two Dassault MD30 Viper turbojets and a SEPR rocket engine, made its first rocket-powered flight in December last year. The prototype Mirage III, which is powered by a single 9,900 lb.-thrust SNECMA Atar G. turbojet, attained a speed of Mach 1·5 in its trials. It is now being fitted with a SEPR 661 rocket to boost high altitude performance and manoeuvrability. Unfortunately, it was not on view at le Bourget.

Ten Mirage III machines are on order for the French air force. They will be fitted with a 13,200 lb.-thrust Atar 9 turbojet with afterburning and, when serving for interception, with a jettisonable SEPR 661 rocket engine. As an attack aircraft, the rocket engine will not be fitted. Lightweight and compact radar equipment and automatic missile-firing control for this aircraft have been developed by GAMD themselves. The aircraft has two readily removable 30 mm. cannon in the fuselage, and under the wings it can carry rockets, bombs, napalm containers, or two external fuel tanks each of 58·5 gallons capacity. Internal fuel tankage is provided for 570 gallons. Integral construction, designed for simple and rapid assembly, has been extensively used in the Mirage, as in other Dassault aircraft.

The Trident II rocket-powered interceptor, ten of which are in "pre-production," is an operational development of the Trident I research aircraft shown at previous Salons by the Sud-Ouest constituent company of what is now Sud Aviation. Ultimately, this aircraft is to be developed as a non-piloted ground-to-air missile. In comparison with the Trident I, the fuselage lines have been improved and the aircraft is now fitted with full-span high-lift flaps. The Trident II is powered by two 2,400 lb. thrust Turboméca Gabizo turbojets installed in wing-tip nacelles, and a 6,600 lb. thrust SEPR rocket in the lower rear part of the fuselage. Dive brakes are fitted on the upper part of the rear fuselage above the rocket engine. Later versions of the Trident II will have afterburning Gabizo turbojets, each developing 3,300 lb. thrust, and it is expected that the fully developed Trident will easily attain a speed of Mach 2. The aircraft can climb to 50,000 ft. in 2 min. 30 sec. and will take off and land within 500 yards. The all-up weight of the Trident is 11,355 lb., of which 4,995 lb. comprises fuel and oxidant. It has a span of 22 ft. 6 in., a length of 42 ft. 6 in., and a height of 10 ft. 3 in. The area of the wing, which is of rectangular plan form, is 155 sq. ft. The armament comprises an air-to-air guided missile below the fuselage.

The Durandal prototype interceptor is powered by an Atar turbojet and a SEPR rocket engine. Sud Aviation.

PILOTED RAMJET

A different mixed-power conception is typified in the Leduc 022 supersonic interceptor designed and constructed by Société René Leduc et Fils, 158 Quai de Bezons, Argenteuil (Seine-et-Oise), which flew for the first time in December last. This aircraft, now undergoing trials, was not displayed at the Salon. Here, the entire fuselage constitutes a thermo-propulsive duct, or ramjet, which does not, of course, become effective as a means of propulsion until the aircraft has reached an appreciable speed. To get the aircraft off the ground and accelerate it to this speed, a SNECMA Atar turbojet is installed within the body of the ramjet. Fuel is carried in the wings and between the double walls of the fuselage duct—the fuel accounting for some 30 per cent. of the all-up weight of the aircraft, which amounts to 18,200 lb.

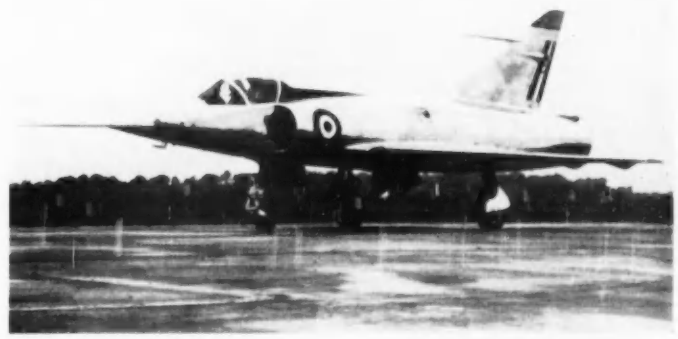
At the estimated maximum speed of Mach 2, the ramjet is said to exert an equivalent ground level thrust of 132,000 lb. The estimated specific fuel consumption is 25 lb. per lb. thrust per hour. The Leduc 022 is a low wing monoplane with 30 deg. of sweepback. All the wheels of the retractable tricycle undercarriage retract into the fuselage shell—the main wheels turning through 45 deg. and the nosewheel through 90 deg. during retraction.

Another ramjet powered piloted aircraft—a field in which only France has ventured—is the Griffon II experimental delta-wing aircraft designed and constructed by Société Nationale des Constructions Aéronautique du Nord, 12bis, Avenue Bosquet, Paris 7, which flew in its present form for the first time in January this year, and which flew with the ramjet in action for the first time on April 26. (The airframe, it should be noted, had already been extensively flight-tested with a different engine installed.)

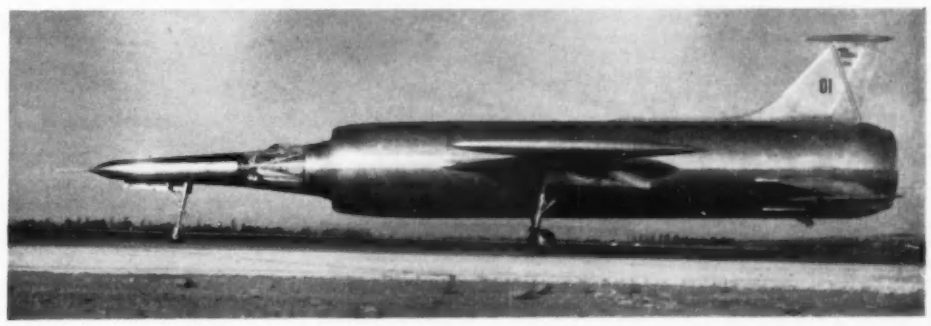
As in the Leduc machine, the 7,700 lb.-thrust Atar E turbojet engine is mounted coaxially within the ramjet duct. In its tests to date, the aircraft has been flown on about four/fifths of the maximum thrust available, and has attained a Mach number in level flight of 1·08.

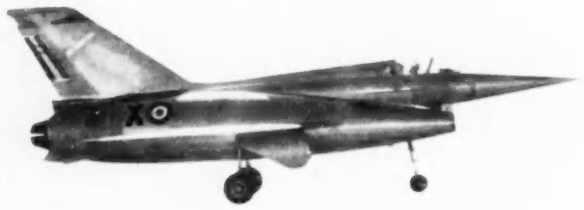
The Griffon II has an unusual configuration, with a delta-shaped longitudinal stabilising surface forward of and slightly above the main 60 deg. delta wing, as well as a small tailplane. The delta wing has a very low thickness/chord ratio. Designed to operate from all types of airfield, the Griffon II utilises low pressure tyres, high lift flaps and a landing parachute. The weight of the aircraft is about 13,000 lb.

(Right) The prototype Mirage III interceptor. Production machines are to be equipped with a jettisonable rocket engine for high altitude interception. GAMD.



(Below) The Leduc 022 ramjet interceptor. René Leduc.





The Nord Griffon II experimental aircraft is powered by a turbo-ramjet and has a longitudinal stabiliser forward of the main delta wing. S.N.C.A.N.

Fig. 7 The twin-jet Breguet 1100 tactical fighter is to be evaluated by the French Navy. Louis Breguet.

Fig. 8 The French Navy have ordered 105 Alizé anti-submarine aircraft. Louis Breguet.

It has a span of 26 ft., a length of about 46 ft., and a height of 13 ft.

FAST CLIMBER

The Nord Griffon was, in fact, developed from the Nord 1402 Gerfaut I power-jet delta-wing experimental aircraft which was shown at the 1955 Salon. Another development from this aircraft is the Nord 1405 Gerfaut II, which flew for the first time in May, 1956; it is a single-seat supersonic interceptor prototype powered by a 9,700 lb. thrust SNECMA Atar G turbojet with afterburner. This aircraft holds two world records for climb—having attained an altitude of 3,000 m. (9,850 ft.) in 50 sec., and 15,000 m. (49,300 ft.) in 3 min. 35 sec. The all-up weight, fully loaded, of the Gerfaut II is 11,700 lb. It has a span of 21·9 ft., a length of 37 ft. and a height of 13·8 ft.

TACTICAL SUPPORT AIRCRAFT

At the 1955 Salon, Dassault showed a model of a lightweight twin-jet tactical-support project, the Mystère XXII. A year later this aircraft, with a 45 deg. swept-back wing of 6 per cent. thickness/chord ratio, flew for the first time, powered by two 2,420 lb. thrust Turboméca Gabizo turbojets. Almost simultaneously a more powerful sister aircraft, with a similar airframe, but with a 7,700 lb. thrust SNECMA Atar E3 turbojet, made its maiden flight. These two aircraft were later renamed, respectively, the Etendard II and Etendard IV.

The Etendard IV is remarkable for its handling over a wide speed range, being supersonic in level flight and yet controllable at really low speeds. It is said to be the only supersonic aircraft that has taken off from, and landed on, grass airfields. Its armament can comprise cannons, installed internally, and ecternal loads such as bombs, rockets or napalm tanks. In addition, it has a large fuselage bay which can accommodate a large-capacity rocket launcher, an auxiliary tank, or a photographic installation. A naval version of the aircraft is now under construction for evaluation by the French Navy.

Another member of this family, the Etendard VI, was designed to a NATO specification for a tactical support fighter, in which the emphasis was on good take-off and landing characteristics, high performance at sea level, and a high rate of roll. This aircraft, powered by a 4,850 lb. thrust Bristol Orpheus turbojet, flew for the first time on March 15 this year. Three prototypes have been ordered by NATO.

Another lightweight tactical fighter to NATO'S specification, the 1001 Taon, which was forecast at the 1955 Salon by Société des Ateliers d'Aviation Louis Breguet, 24 Rue Georges-Bizet, Paris 16, has not yet made its appearance. We understand that it is being redesigned to conform with the area rule, with a " wasp-waisted " fuselage.

The twin engine Breguet 1100 single seat tactical fighter which was outlined at the same time as the Taon has, however, made its maiden flight in April this year, and exceeded Mach 0·9 in its early test flights. Of three prototypes on order, one is destined for the French Navy where it will be evaluated in competition with the Etendard IV. Powered by two Turboméca Gabizo turbojets, it has a length of 41·3 ft. and a height of 14·3 ft. Wing dimensions have not been released. Its all-up weight is about 13,000 lb.

AIRCRAFT IN SERVICE

Leaving now the prototype and pre-series aircraft, and turning to another Breguet aircraft seen for the first time, but already in production, the Breguet 1050 Alizé three-seat carrier-based anti-submarine aircraft, of which 105 aircraft are on order for the French Navy and four have already been delivered, is a development of the Breguet 960 Vultur which was seen at the 1953 Salon (ENGINEERING, July 17, page 74, 1953).

The Vultur had an unusual configuration, with a Mamba propeller-turbine in the nose and a Hispano Suiza Nene turbojet in the tail of the aircraft. In the Alizé, the Nene engine has been removed and replaced by a retractable radar scanner; and, in place of the Mamba engine, a 1,975 h.p. Rolls-Royce RDa7 Dart propeller turbine is fitted. The all up weight of the aircraft is 17,600 lb.; it has an aspect ratio of 6·8, a span of 51 ft. 2 in. and a length of 45 ft. The cruising speed is 130-230 knots and it has an endurance of over 4 hours. No details are available of the varied armament it can carry for use against diving and surfacing submarines, or of the comprehensive detection apparatus and radio systems installed.

Among the combat aircraft in production for the French services, the Dassault Mystère IVA, now in peak production, has been supplied in large numbers to India and Israel as well as to the French air force. The supersonic Dassault Super Mystère B2 multi-purpose attack aircraft, of which 370 are on order, is expected to enter service this year, as is also the twin-Atar Sud Aviation Vautour, in two forms—a two-seat allweather fighter, replacing France's Gloster Meteors, and a bomber version. The Vautour, which has a speed of over 680 m.p.h. at low altitude, a rate of climb of 11,800 ft. per minute and a range of 2,500 miles, has given a very satisfactory performance as a bombing platform at high altitudes, and manoeuvres well at near-sonic speed. A total of 300 Vautours are on order, including a third single-seat tactical-support version.

MISSILES

Four organisations are actively engaged on missile production—the government armament establishment Directions des Études et Fabrication d'Armement (DEFA); Société Matra, an associate of the Breguet company; S.N.C.A.N.; and Sud Aviation. In addition, Breguet and Dassault are known to be working on missiles; and SEPR are responsible for many of the rocket power plants, both solid and liquid-fuelled, which propel the missiles.

Information released by the French authorities mentions three air-to-air missiles in production—the Matra M.20, powered by a liquid-fuel rocket, with a range of about 5,200 ft., and a speed of Mach 1·5; the Matra M.501 with a solid-fuel rocket, and a speed of Mach 1·5; and the Nord 5103, powered by a solid-fuel rocket, with a range of about 13,000 ft. and a speed of Mach 1. Still in the experimental stage is the Matra M.04—with a liquid-fuel rocket and a speed of Mach 1·5.

One surface-to-air missile is in full production —the DEFA Parca, which has a ceiling of 14,750 ft. and a speed of Mach 1·7, and is powered by a liquid-fuel rocket. Sud Aviation have developed two experimental surface-to-air missiles, both powered by liquid fuel rockets—the 4100, which has a ceiling of 39,000 ft. and a speed of Mach 0·8, and the 4300, of which no performance details have been released officially. Two other surface-to-air weapons about which no information is revealed, are the Maruca and Masalca, under development for the Navy, and, as already mentioned, the Sud Trident interceptor aircraft is ultimately to be developed as a long-range ground-to-air missile.

Four surface-to-surface missiles are in production—all subsonic. The Sud Aviation S.A. 4200 is powered by a ramjet and a solid rocket, and has a range of about 75 miles. The other three short-range weapons are all propelled by solid rockets; the DEFA Entac, with a range of about 5,200 ft., and the Nord SS10 and SS11 with ranges, respectively, of 5,200 ft. and 11,500 ft. The Nord SS10, and also their two target missiles, the Nord C.T.10,propelled by a pulse-jet, and C.T. 20, with turbojet, have been supplied to other countries.

Two experimental high-altitude research vehicles have also been named, both propelled by liquid fuel rockets: the Véronique, which attains a speed of Mach 2 and a ceiling of over 150 miles and the Monica, with a speed of Mach 4 and a ceiling of 6·5 miles.

The Iron and Steel Institute

THE BIRTH OF AN INDUSTRY

The foundation of the iron and steel industry in the Netherlands is of quite recent date and the man who took the initiative in its establishment, H. J. E. Wenckebach (1861-1924) came to the conclusion, after a detailed study of the position, that an enterprise located at Ijmuiden, on the sea coast could compete with older industries in other lands because it would be able to receive the needed raw materials at its own seaport and distribute its products cheaply along waterways.

In describing the birth and subsequent growth of the Dutch steel industry, in his presidential address to the Iron and Steel Institute, delivered in London on May 22, Mr. A. H. Ingen-Housz, President of the Royal Netherlands Blast Furnaces and Steelworks, Limited, Ijmuiden, added that the advantage enjoyed by the works at Ijmuiden in the matter of transport costs would increase with the years. The old-established enterprises would have to face increasing exhaustion of their raw-material resources, and would thus become committed to the more expensive solution of supply by rail or, if from overseas, by repeated transhipment.

Continuing, Mr. Ingen-Housz stated that the preparations for the development of the Dutch steel industry had started in 1917, but the implementation of the plans had been retarded by the war of 1914-18. The decision then arrived at was that the construction of a blast-furnace plant would have to suffice for the time being and a careful study of blast-furnace plants in various countries, particularly those in Belgium, the Ruhr area, the United Kingdom, and the United States, had led to the adoption of the United States-type of blast-furnace installation.

When, in 1924, the first Ijmuiden pig iron had been put on the market, the works authorities were convinced that they would not be able to sell their products as mass-produced articles, but would have to find new selling techniques. The company, by appointing their own repsentatives and by introducing the pig in the form of special brands, had laid emphasis on the good quality of the iron. Another device had been to adapt the various grades of iron to the special needs of their clients, after close consultation with them.

Once the pig-iron production had become a technical and economic success, attention had not been directed immediately to the manufacture of steel but to the processing of by-products. Progress had been continuous and the synthetic-ammonia plant now produced 500,000 tons of nitrogenous fertilisers a year and the annual production of blast-furnace cement would shortly pass the half-million tons mark.

At length, construction of the steelworks had begun in 1938, and, in succession, four 80 ton open-hearth furnaces had been completed. A rolling mill, started in 1939, was destined for the production of plates intended primarily for the shipbuilding industry. Its annual production was at first 120,000 tons, but its capacity had been increased several times and would shortly reach between 350,000 and 400,000 tons a year. The maximum plate weight then would be 9½ tons and the maximum net width 110 in. The necessary post-war expansion in steel production had been achieved by the construction of two additional 200 ton open-hearth furnaces, and by enlarging the four existing 80 ton furnaces to 200 tons. These developments, among other things, had meant a changeover from gas to oil firing.

Recently, an important speeding up of open-hearth steel production had been obtained by the adoption of de-siliconisation, a pre-treatment now applied to all molten iron. With 50 per cent. hot metal, the heating time in the furnace was reduced by about 10 per cent., which meant about one hour for a 200 ton charge. Many new installations had been added to the Ijmuiden works in the course of the past 10 years and the most important of these was a wide-strip rolling mill. The techniques of inspecting and testing the final products had also been much improved.

* * *

LOW-ALLOY STEELS CONTAINING BORON

In the United States, during the war of 1939 to 1945, it was found that additions of boron, of the order of 0·003 per cent., to hardened and tempered medium and high-carbon low-alloy steels, could replace, in certain circumstances, some of the manganese, nickel, chromium and molybdenum contained in the steels, and boron was employed, therefore, to conserve supplies of these valuable alloying metals.

In this country, the Research and Development Department of the United Steel Companies Limited, Sheffield, some eight years ago, conducted a detailed investigation into the effect of boron on steels but, in this case, the materials were low-carbon low-alloy steels in the as-rolled or normalised condition. The investigation was described in a paper presented before the Iron and Steel Institute and published in its *Journal*, volume 163, page 277 (1949). The paper was entitled " Mechanical Properties of Low-Carbon Low-Alloy Steels Containing Boron " and the authors, Mr. W. E. Bardgett and Dr. L. Reeve, stated that a steel containing 0·14 per cent. of carbon and approximately 0·40 per cent. of molybdenum, with 0·0016 per cent. of boron, had a maximum stress of 38·3 tons per sq. in., and a yield stress of 33·7 tons per sq. in., with good ductility and toughness. The corresponding figures for a steel of similar composition, but without boron, were 30·4 and 16·9 tons per sq. in., respectively. Thus the yield stress had been doubled by the addition of 0·0016 per cent. of boron.

Further work had shown that the steel possessing the most attractive properties was the molybdenum-boron steel containing about 0·14 per cent. of carbon, about 0·40 per cent. of molybdenum and 0·003 per cent. of boron. The weldability of this steel had proved to be particularly good and it was now manufactured and sold in the form of plates, channels and other rolled sections under the registered trade name of " Fortiweld."

On May 22, during the annual general meeting of the Iron and Steel Institute, held in London, Dr. K. J. Irvine, Mr. F. B. Pickering, Mr. W. C. Heselwood and Mr. M. Atkins, of the metallurgy and physics sections of the Research and Development Department of the United Steel Companies, presented a paper in which the " Physical Metallurgy of the Low-Carbon Low-Alloy Steels Containing Boron " was considered. It is thus evident that the usefulness of the molybdenum-boron steels having been established, the present research was undertaken to explain the nature of the changes occurring in the material and to account for the improved mechanical properties obtained. The authors stated that the transformation characteristics of these materials had been examined isothermally and on continuous cooling. Boron had been found to exert a maximum effect at about the solubility limit for Fe_2B at the austenite grain boundaries. Of the alloying elements, molybdenum up to 0·5 per cent. had been shown to have a major effect when present with boron, and this was to retard polygonal-ferrite formation and, to a lesser extent, the upper bainitic-ferrite formation. Carbon had very little effect on the transformation diagram over the range 0·01 to 0·20 per cent. C.

The mechanical properties of the steels were directly related to the type of transformation product and the improved properties were obtained whenever the transformation to bainitic ferrite occurred.

Another paper presented at the same session of the meeting dealt with " The Strain-Ageing of Boron-Treated Low-Carbon Steels " and described work conducted in the United States. The authors, Mr. E. R. Morgan and Mr. J. C. Shyne, stated that the aim of their research had been to examine the feasibility of boron additions to eliminate strain-ageing, namely, the usually detrimental time-dependent changes occurring in the properties of cold-worked material during storage, which strain-ageing was caused by nitrogen in alloys of commercial composition.

The results had shown that, for all practical purposes, boron-treated box-annealed low-carbon steels containing from 0·007 to 0·02 per cent. of boron were non-ageing. A consideration of economics, ingot segregation, and the boron-oxygen equilibrium had shown that, for the rimming grade of open-heartl steel, the most promising level of boron additions was in the region of 0·007 per cent.

THE ALL-BASIC OPEN-HEARTH STEEL FURNACE

The working hearth of a basic open-hearth steel-making furnace is composed of magnesite or dolomite (basic) refractory materials but, until recently, the roof was constructed entirely of (acid) silica bricks. Some years ago chrome-magnesite bricks (usually referred to as " basic bricks ") were introduced for lining the furnace ports and their adoption for constructing the furnace roof is receiving increasing support. For this reason a paper entitled " Co-operative Trials on All-Basic Furnace Roofs," presented at the annual general meeting of the Iron and Steel Institute in London, on May 23, by the All-Basic Furnace Sub-Committee of the British Iron and Steel Research Association and the British Ceramic Research Association, contained much to interest steelworks metallurgists and engineers.

The trials carried out were essentially trials of basic bricks in roofs; the performance of bricks in other parts of the furnace was not a major consideration. The bricks used in all the trial furnaces were made by four United Kingdom and two Austrian manufacturers. Only fired products were employed, but these included both chrome-magnesite (" C/M ") and magnesite-chrome (" M/C ") bricks. The chrome-magnesite bricks contained some 39 to 49 per cent. of MgO and 24 to 34 per cent. of Cr_2O_3 with roughly 10 per cent. each of alumina and ferric oxide and smaller quantities of other compounds. The magnesite-chrome bricks contained, on an average, upwards of 60 per cent. of magnesite, with some 14 to 17 per cent. of Cr_2O_3, less than 10 per cent. each of alumina and ferric oxide and smaller quantities of other substances. It was not always practicable to make all the trial roofs with more than one type of brick but of the eleven furnace roofs under trial, seven were " panelled " to enable comparisons of bricks of different properties and compositions to be made.

The eleven all-basic furnace campaigns took place under normal operating conditions at four steelworks, namely, the Bilston Works of Stewarts and Lloyds, Limited, the Consett Works of the Consett Iron Company, Limited, the Steel, Peech and Tozer Works of the United Steel Companies, Limited, and the Ijmuiden Works of the Koninklijke Nederlandsche Hoogovens en Staalfabrieken, N.V., Holland.

The authors state that the results of the trials have shown that the design and operation of an all-basic furnace have a far greater influence on the life obtained than have observed differences in brick quality. The M/C bricks which gave an outstanding performance (1,989 casts) at Bilston were of the same brand and had properties very similar to the M/C bricks that gave

lives of 275, 179 and 213 casts at the other three plants. It is considered that the attempts made at Bilston to minimise the movement of the roof bricks and maintain a limited temperature variation (1,680 to 1,600 deg. C.) for most of the campaign are factors of paramount importance.

In spite of the dominance of these operational and design factors, and although the information gained from the trials does not justify the placing of the bricks in a definite order of merit, it is possible to draw certain conclusions on brick quality from the trial resuts. Thus, volume stability at 1,700 deg. C., and good refractoriness-under-load values, or low creep rate, are important properties. The roof bricks all failed by peeling or the shelling of pieces from 1 to 1½ in. thick, referred to as the " slabbing " of the surface, and resistance to thermal shock is therefore a desirable property.

The sub-committee feel that the development of the all-basic furnace can best be forwarded by the study of further trial roofs, but it can be speeded up by recourse to pilot-scale work, where new (and possibly risky) ideas, including tests at abnormally high temperatures can be tried out more quickly and safely than on production furnaces.

APPLIED SCIENCE

New Developments at the National Physical Laboratory

The National Physical Laboratory, responsible for maintaining the national standards of mass, length, and time—and also the less familiar photometric and electrical standards—held two " open days " recently. Fundamental research programmes, the accurate determination of physical constants, and the investigation of special problems are among the other activities of the Laboratory. The open days at Teddington, Middlesex, provide an opportunity for visitors to see something of the broad scope of the work done there. It is hoped that any visitors who find that sections of the Laboratory's work are especially related to their own problems will make arrangements to return and discuss them in detail.

The variety of work carried out in the laboratories gives rise to a variety of buildings: from the old royal residence to the high-voltage laboratory with its 4 ton terminal poking through one wall. And within the laboratories the equipment is similarly diverse: devices with immaculately machined surfaces contrast with apparatus built largely out of Meccano. Teddington, perhaps to a greater degree than any other establishment, serves as a meeting point for academic science and practical engineering. A feature of the Laboratory is the manner in which unfamiliar physical effects are put to productive use.

A typical instance is the machine tool monitor that was shown working under the control of a diffraction grating. A lathe was cutting 1,000 threads to the inch and the movement of the saddle holding the cutting tool was being recorded by the detection of the moving system of moiré fringes caused by the relative movement of diffraction gratings. Two gratings are used. Each consists of a piece of glass covered with parallel lines, ruled accurately at 1,000 to the inch. A short grating is fixed to the moving saddle and a long grating is fixed rigidly to the lathe bed. By arranging the lines on each grating to slope in opposite directions a trellis pattern is formed. As the saddle moves along the work, one grating moves parallel to the other, so that a light situated at a fixed point and shining through the two gratings will sometimes be obscured and sometimes be free to shine through. In fact, the light transmitted goes through a sinusoidal cycle every time that the moving grating travels 0·001 in. By detecting the light with a photo-transistor, a sinusoidal electrical output is obtained. Since the object of the measurement is to ensure that the saddle moves 0·001 in. on every complete rotation of the mandrel, it is necessary to have an electrical signal corresponding to the actual rotation. This is achieved by a potentiometer situated on the end of the mandrel. A saw-tooth wave is obtained from the potentiometer and the two sets of signals are passed into an electronic phase comparator. A current proportional to the phase difference existing between the two signals is passed to a pen recorder which gives a constant display of the error occurring in the cutting process. As an alternative, a servo system is being developed which uses the error signal to operate a feedback system which, by means of a servo motor, adjusts the saddle movement to minimum error. The technique lends itself reaily to other machine tools.

WIRE IN PRESTRESSED CONCRETE

One of the projects in the metallurgy department has been the study of the effect of fire on hard-drawn steel wires in prestressed concrete beams. Under severe heat the wires deform plastically and loss of prestress occurs, leading to collapse. At failure the surface of the beam may exceed 1,000 deg. C., although the wire may only reach 400 deg. C. It has been confirmed by tests that this temperature is reached within 2 to 4 hours of the commencement of the fire. It is also found that considerable losses in strength occur by the time the wire temperature reaches 150 deg. C. From the results of the research it would appear desirable that the undersides of prestressed concrete beams should be thermally insulated, and that some method of reloading the wires should be developed.

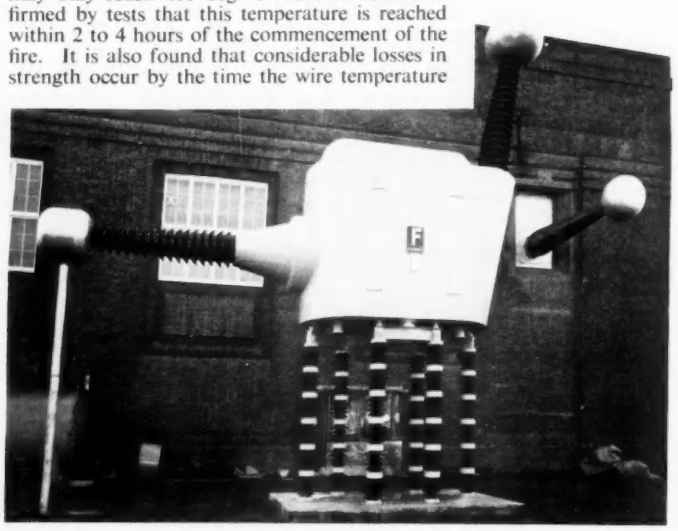


Fig. 1 The new testing transformer at the National Physical Laboratory gives a single-phase output of one million volts. The porcelain bushing in the wall of the high-voltage laboratory allows the full output of the transformer to be used in the building.

The effects of cyclic speed on the fatigue strength of mild steel at high temperatures is also under investigation. It is found that there is a reversal of normal behaviour when the temperature range between 200 and 300 deg. C. is reached. In this range the strength is greater at 10 cycles per minute than at 2,000 cycles per minute. It is thought that this is due to strain ageing.

The changes of the elastic constants of steels with tempering temperature, as shown by ultrasonic pulse tests, are a further subject of study. When the specimen is quenched in oil from 780 deg. C. it is found that in the range of quenching temperature from 0 to 600 deg. C. the rigidity modulus of the specimen varies between 11·1 and 11·8 $\times$ 10^6 lb. per sq. in. Four different modes of variation are discernible throughout the temperature range.

A 1,200 ton compression testing machine has recently been acquired by the Laboratory in connection with the metrology division's programme for the development of precision load-measuring devices which will extend the standard for compressive loads to 1,000 tons. The machine is hydraulically operated and can accommodate instruments, or groups of instruments, on a 26 in. square platen, to a maximum height of 80 in. The machine will be used for standardising load measuring units of 150, 450 and 1,000 tons capacity by building up from three similar 50 ton load measuring units initially standardised in the Laboratory's 50 ton deadweight standard machine.

A device for measuring the pitch errors in the serrations of the " fir-tree " roots on gas turbine discs was exhibited. The difficulty is that the pitch must be accurate to 0·0001 in. but the actual location of the complete root on the disc might be only accurate to 0·001 in. The apparatus developed is shown in the illustration in Fig. 2. The disc is mounted with its axis horizontal and it is rotated to a position such that the pressure flanks of all the serrations on one side of the fir-tree root being measured are vertical. The pitches, or horizontal spacings, are then measured by means of the rotating turret shown in the upper left of the illustration. The measurements are made with reference to the pressure flank of the serration nearest the periphery of the disc. The large upper cylinder is the turret, fitted with several probes each of which hooks into a particular serration in the root. The smaller lower cylinder contains the electro-mechanical transducer and the fixed probe which engages the serration nearest the periphery. The relative distance between the two probes is transmitted mechanically to the back of the transducer. The measurement is performed to the desired accuracy by comparison with a composite slip gauge standard and the pitch errors recorded on a chart. The indexing mechanism, shown in the bottom right of the illustration, rotates the disc and brings each root in turn to the measuring position. The alternate operation of the indexing and measuring mechanisms is carried out automatically.

A pneumatic instrument was shown that was capable of measuring thin plastic film or metal foil to an accuracy of 0·00001 in. The material is placed on a small table which locates it between two air jets, so that it is measured free from compression. The difficulty of providing accurate standards of thickness in the range 0·001 to 0·01 in. is avoided by fitting an independent third jet and adopting a technique which enables slip gauges of size 0·1 in. and larger to be used as standards.

A new testing transformer, shown in Fig. 1, has been sited close to the high voltage building. It is a single unit rated at 700 kVA and designed to give a single phase output of one million volts when supplied at 1,200 volts. The winding of the transformer is immersed in oil in a steel tank, the whole assembly weighing approximately 55 tons. The tank is connected to the centre point of the high-voltage winding, and as it is always at half the output voltage it is insulated from earth by three pairs of porcelain columns; these columns can withstand 500,000 volts without flashover. Two 500,000 volt bushings are fitted to the tank, one for the

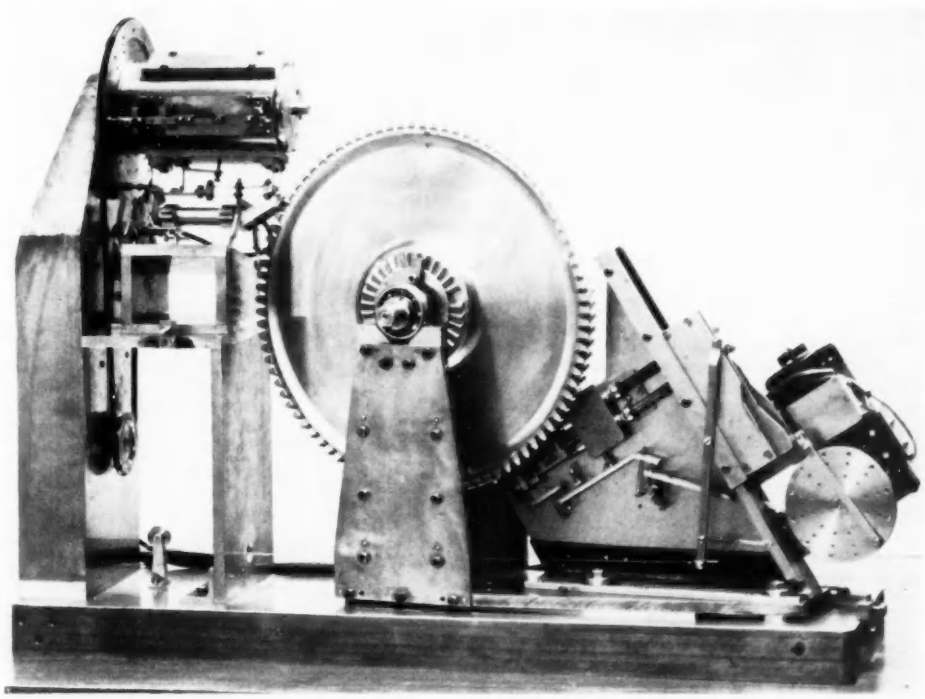


Fig. 2 The tolerances on the pitch of the serrations in fir-tree roots for gas-turbine blades are only a few ten-thousandths of an inch. The device shown automatically measures the errors on each root in turn.

supply to the primary winding and the other for the output. A million volt porcelain wall bushing 36 ft. long and weighing 4 tons is mounted in the wall of the laboratory so that the full output of the transformer can be used inside the building.

FASTER COMPUTER

The new digital computer, ACE, will be ready soon to execute its first test programmes. The design of this machine is based on the experience in logical design and engineering techiques gained with the experimental ACE pilot model (which was in regular computing service in the mathematics division for four years) and also from DEUCE, which is an engineered version of the ACE pilot model. The new ACE has a main store of 32,768 words and a computing store of 808 words. As in DEUCE, the two stores are a magnetic drum and mercury delay line respectively. The capacity of the earlier machine was only 8,125 and 400 words.

An increase in speed by a factor of 8 has been achieved, partly by means of the use of a three-address system instead of a two-address system. Whereas the DEUCE required 184 microseconds to perform two consecutive additions, the same operation is performed by ACE in 64 micro-seconds, using the new system. The use of mercury delay lines in the rapid access store has been continued since they have been found very reliable in practice. Lines 5 ft. long are used to store 1,536 pulses which take one millisecond to travel the length of the mercury column. The pulses are derived from a 15 Mc/s carrier and are a microsecond wide. Shorter lines are also used which store 192, 96 or 48 pulses. The machine uses valves in preference to crystal diodes.

Experiments have been made with DEUCE on the use of learning in calculation. The index of about 30 million insured people that is kept by the Ministry of Pensions and National Insurance has been studied as a concrete example. Problems are being solved by using a learning machine which judges from past experience what variant in the index to try when a particular entry is being sought. An earlier experiment was the teaching of the machine to play noughts and crosses. The technique was quite different to that of building the strategy of the game into the design. The machine lost its early games but gradually improved with experience until it was finally sufficiently skilful never to lose.

Research on a different form of delay line for use in computers is also in progress. A stable torsional wave delay line, in which a pulse travels in a steel wire for 5 milliseconds, has been produced. Barium titinate transducers are used and each line stores 1,000 pulses. A feature of the line is the use of R31 steel wire, which has a temperature coefficient of delay of 6 parts per million per deg. C. The transducer element, which is 0·036 in. long, 0·157 in. external diameter, and 0·050 internal diameter, is made in two halves. These are circumferentially polarised and cemented together. When a voltage is induced on the end face of the transducer it twists, sending a torsion wave down the wire, at the other end of which it is detected by a similar transducer.

Knowledge of the thermal properties of materials is becoming of considerable importance. A new device was displayed which offered a simple comparative method which, from observations taking only a few seconds, could furnish approximate values for the thermal conductivity of any sample having a hard smooth surface. The method is based on the common experience that by merely handling solids at normal temperatures they can be roughly graded in order of their thermal conductivities. Good thermal conductors abstract more heat and thus feel colder than poor conductors. In the device exhibited, a small phosphor-bronze ball, heated to a constant excess temperature, was brought into contact with the test surface and its rate of cooling observed. As might be expected, this depends on the applied pressure and the nature of the surface, but when calibrated for a material of known thermal conductivity, and used under comparable conditions, thermal conductivities can be evaluated for a wide range of solids, both metallic and non-metallic. A block of balsa wood was used to mount two balls—one being in contact with the surface being measured, and the other not. Thermocouples, differentially connected, were used for measuring the temperature difference of the two balls. Observations need only cover a period of 10 seconds. It is also possible that the device could be used to study surface conditions or measure foil thickness.

A novel source of microwaves in which ½ milliwatt of power at 5,400 Mc/s was obtained from a 6 volt mercury arc was demonstrated. The device is made possible by the inherent stability of very short mercury arcs. The length of the arc in the microwave-generating state is less than 10 microns, and occurs in the dimple formed by dipping a red hot tungsten wire anode in a mercury cathode. The high temperature of the anode, coupled with the evolution of mercury, prevents metallic contact between the anode and the cathode. The microwave output is coherent and consists of relatively sharp peaks superimposed on a background of noise extending to a frequency greater than 36,000 Mc/s. A tuned circuit can be used to select the frequency desired. Power consumption is about 2 watts.

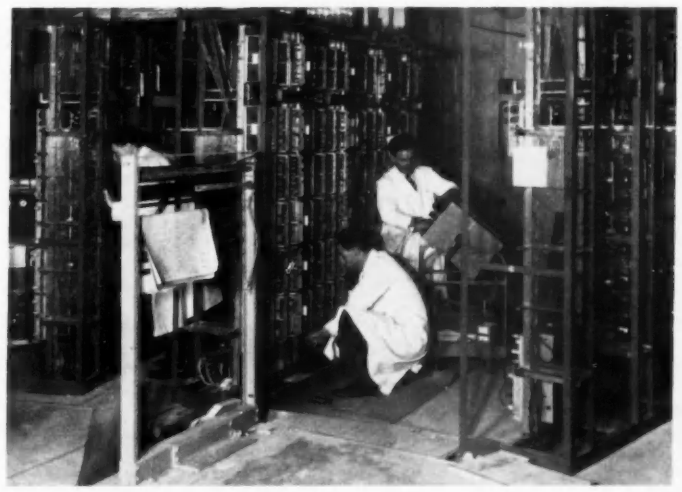


Fig. 3 The new digital computer, ACE, will shortly be ready to execute its first test programmes. Its speed is about eight times that of DEUCE.

OSCILLATIONS ON THE SEA

Theoretical calculations for predicting the motions of a ship in rough water depend upon a knowledge of the value of various factors. Factors such as the entrained water inertia coefficient and the damping coefficient are dependent upon the shape of the hull, and although theoretical calculations can be made to estimate their value, few experimental data are available to check the accuracy of the calculations.

Experiments are being carried out to determine the values of the entrained water inertia coefficient and the damping coefficient for a number of different hull forms. The experimental results will be compared with calculated values. As a simplification of the problem the motion of the model is restricted to one plane. A further simplification is made to the analysis by force-pitching the model in calm water by means of a system of rotating weights. In this way a known cyclic variation of pitching couple will produce an angle of pitch and a coupled vertical motion of the centre of gravity. This type of controlled experiment enables an analysis to be made of the restoring moments acting upon the model in opposition to the applied couple.

Measurements are made of the angle of pitch, the heave of the centre of gravity and the phase relationship between these two motions and the applied couple. All these functions are recorded continuously during an experiment. The frequency of the applied couple can be varied over a considerable range to include the resonant frequency. The effect of the forward velocity of the hull factors is also under investigation.

VIBRATION AND NOISE OF MECHANISMS AND MACHINES

CAUSES AND REMEDIES

By A. J. King, M.SC.TECH., D.SC., M.I.E.E., F.INST.P.*

This paper, written at the request of a committee of the Mechanical Engineering Research Laboratory, East Kilbride, surveys the problem of reducing the vibration and noise of mechanisms and machines. It introduces the physical and subjective aspects of vibration and noise, giving the units and methods of measurement. Common causes of vibration and noise especially affecting mechanisms and machines are given with examples to illustrate important cases. Methods of reduction are then considered, the treatments appropriate to the various types of disturbance being given with examples. In particular the importance of resilient mountings and enclosure are stressed and the need for further research on rolling and sliding contact of metals on each other is pointed out. The problem calls for a wide appreciation of all the relevant factors and possible lines of attack in order to choose the best solution.

Practically all types of mechanisms and machines give rise to vibration and noise when they are operating. Until recent years the vibration and noise were regarded as inevitable and even in some cases as an indication of the magnitude of the power involved. It is now realised that both are undesirable from two points of view, that of the machine and that of the operatives and other persons near. As far as the machine is concerned, vibration and noise are nearly always indications of wastage of energy although the amount of power radiated as noise may be only of the order of one watt. The wasted energy is also often accompanied by excessive wear, so on both these counts any excessive vibration and noise deserve very critical examination. The effects on operatives and other persons near may range, in the case of vibration, from a mild irritation to an attack of Raynaud's disease and, in the case of noise, from interference with sleep to partial or complete deafness. It is clear that the problems of vibration and noise from mechanisms and machines call for very serious study as to their causes and methods of avoiding or reducing them, and some aspects of these problems are considered below.

VIBRATION

Units.—Most engineers in this country think of vibration in terms of the double amplitude of the movement and they express this in thousandths of an inch, contracted to "thous" or "mils." The more mathematically inclined prefer to use the single amplitude and quote it as "plus and minus so many thous." This use of amplitude has probably arisen partly due to the early methods of measurement and partly to the engineer's continual concern with permissible clearances and stresses. However, where the radiation of noise from a vibrating surface is involved, the magnitude of the oscillatory velocity of the surface in a direction normal to its plane is much more important than the amplitude, since, with the area of the surface, it defines the "strength of the source" of sound. As has been pointed out[1], there is something to be said for adopting 5×10^{-6} cm. per sec. or 2×10^{-6} in. per sec. as the unit of vibration velocity where sound radiation is concerned, but the late H. G. Yates and the writer did not receive general support for this unit. It is also convenient where sound radiation is concerned to express the velocity on a decibel scale by which in terms of 10^{-6} cm. per sec., an oscillatory velocity of v cm. per sec. r.m.s. becomes 20 log $(v \times 10^6)$ db. Bruel[2] has suggested a similar scale based on a threshold velocity of 0·0312 cm. per sec., irrespective of frequency, his vibration units for a velocity of v cm. per sec. being 20 log $\left(\frac{v}{0{\cdot}0312}\right)$. He calls these units "pal."

When the consequences of a vibration are dependent on acceleration, it is usual to adopt as a unit the acceleration due to gravity, approximately 386 in. per sec. per sec. or 981 cm. per sec. per sec. This situation arises, for example, when a system receives an impulse and the forces involved are determined by the mass and acceleration of the parts of the system concerned. Table I illustrates the magnitudes involved.

Subjective Response.—The response of human beings to vibrations of different frequency and amplitude has been studied by several investigators[3, 4, 5], and Postlethwaite[6] has attempted to reduce the available information to a set of curves corresponding to typical levels of vibration sensation. These curves indicate that at one cm. per sec. the human body is acceleration-sensitive, 0·12 in. per sec. per sec. or $3{\cdot}1 \times 10^{-4}g$ being the threshold and $1{\cdot}2 \times 10^{2}$ in. per sec. per sec. or $3{\cdot}1g$ intense vibration, while at 10 cm. per sec. the response is related more to velocity, the corresponding acceleration limits being 1·2 in. per sec. per sec. for threshold and $1{\cdot}2 \times 10^{3}$ in. per sec. per sec. for intense vibration. The above determinations were carried out on a small number of subjects so, until further tests are made on many more subjects, covering sex, age and method of application, the results quoted should be regarded as approximate only.

Measurement.—The early methods of measuring vibration amplitudes, involving falling smoked glass plates or rotating smoked cylinders, gave way to recording on paper tape or scratching on cellulose tape with subsequent optical amplification. These methods, which depend on having a fixed reference point, are still used at low frequencies where amplitudes are comparatively large, but they have been supplemented by more modern methods,[1] mostly electronic, although some are direct-reading without amplification. A big advantage of the modern methods is that it is no longer necessary to have a fixed reference point, as small mechanical-electrical transducers, or "pick-ups," are available for attaching to vibrating parts to measure the absolute vibration without reference to a fixed point. Many of these transducers are piezo-electric accelerometers, the piezo-electric element generating a voltage proportional to the force required to accelerate a known mass. Others are of the moving-coil type in which either the permanent magnet or the moving coil is supported flexibly so as to create a more or less fixed reference point in space. These two types of transducer, giving voltages proportional, respectively, to acceleration and velocity, account for most of the vibration measuring pick-ups used in practice but there are a few others[1] which depend on resistance strain gauges, changes in reluctance of a magnetic circuit and changes in capacitance of an air gap. The calibration[1, 7] of these vibration measuring devices is usually effected by vibrating tables or beams, the vibration of which has been determined by optical or moving-coil means. However, in some cases, it is possible and convenient to calibrate two pick-ups bolted together by reciprocity technique.[8, 9] This is particularly so at high frequencies where other methods are difficult. A further important advantage of electronic methods of measuring vibration is the ease with which the motion can be analysed[1] into its components, thus facilitating the diagnosis of the causes of these components and the specification of remedial measures.

NOISE

Units.—Noise is defined[10] as "sound which is undesired by the recipient", so a statement of the magnitude of a noise must cover the subjective aspect of its being "undesired" as well as the objective aspect of a sound wave. The latter is readily specified in terms of the oscillatory pressure in the wave above and below the mean atmospheric pressure, the unit being the dyne per sq. cm. To form a convenient scale of magnitude, a reference pressure of 0·0002 dyne per sq. cm. r.m.s., which is near to the minimum audible, or "threshold," pressure at a frequency of 1,000 cycles per sec., has been chosen. Since the range of sound pressures to which the human ear responds is so large, roughly 10^6:1, and for reasons associated with the law of the ear's response, a logarithmic scale has been adopted. On this scale a sound of p dynes per sq. cm. r.m.s. has a sound pressure level of 20 log $\frac{p}{0{\cdot}0002}$ decibels.

Subjective Response.—The scale of subjective response is complicated by the variation in sensitivity of the human ear with frequency. This variation has been studied by a number of investigators and three sets of equal loudness curves have been produced[11, 12, 13] of which the most recent[13] determined at the National Physical Laboratory, is probably the most representative. For comparisons of loudness of tones the sensitivity of the ear at 1,000 cycles per sec. was adopted as a reference standard at Paris in 1936 and, subject to certain conditions of listening,[10] the decibel scale of sound pressure level at this frequency became the phon scale of equivalent loudness, or loudness level, the units being called "phons." Noises of any degree of complexity are also referred in the same way by aural comparison to the equally loud tone of 1,000 cycles per sec. In this way, by using a relative instead of an absolute scale, the difficult, if not impossible, task of "measuring" subjective responses is avoided.

While the phon scale provides a common basis for rating the loudness of steady sounds of all compositions, the numbers attributed to sounds of different loudness do not agree in relative magnitude with the relative magnitude of the loudness sensations induced in average individuals. The problem of deriving a true loudness scale has been studied by a number of investigators[11, 16, 17, 18] each group producing a somewhat different scale. However, they are in rough agreement that, over the practically important range from 40 to 100 phons, the loudness of a sound is judged by the average individual to be doubled when its equivalent loudness is increased by approximately 10 phons. This value was therefore agreed upon at a recent international meeting in Paris and it is expected to form the basis of a new loudness scale. The units of the scale are arbitrary but it was agreed to make unit loudness that of a sound of 40 phons since this value has been used as a standard in subjective measurements of pitch. The units are called sones and the loudness, L, of a sound of P phons is given by this scale as L = antilog (P − 40) 0·03 sones. While this relation has the merit of simplicity it is approximate only and may be modified slightly in due course by national and international agreement.

As regards intermittent or varying sounds, the B.S.I. has not issued any recommendations beyond the reliance on aural balance with a reference tone of 1,000 cycles per second laid down in B.S.S. 661 for steady sounds.

Measurement.—The determination of the physical magnitude of a sound wave is usually a straightforward measurement with a microphone, amplifier and indicating instrument. This apparatus can be calibrated[14] to read in sound-pressure level and weighting circuits can be included to imitate the pure tone response of the ear at typical levels, usually 40 db, 70 db and over 80 db which has a "flat" response.

* Research Department, Metropolitan-Vickers Electrical Company, Limited.

Such an equipment with an r.m.s. instrument scaled in decibels is called a "Sound Level Meter" and many are in use in Britain, the United States and other countries in compact portable form. While they may read correctly in phons for pure tones, they tend to read low, by up to 10 or more phons, on complex noises for reasons which have been discussed.[16] Alternatively, the apparatus can be fitted with filters which permit the noise spectrum to be analysed into bands of various widths, usually of full, half or one-third octave, or so narrow as to select discrete components. This technique of analysis is again, as with vibration, of great assistance in diagnosing the cause of a noise and in specifying remedial measures as discussed later.

If it is important to have the equivalent loudness of a noise in phons by an objective as opposed to a subjective[12] method it is possible to derive it from an analysis by summation of the contributions of the components. An instrument to carry out this summation has been developed[15] but, although it gives results which accord closely with those given by the fundamental reference tone technique[12] for many practical noises having discrete components, it tends to read low, in phons, although not as low as the sound level meter, on noises having a continuous spectrum covering wide bands of frequencies.

COMMON CAUSES OF VIBRATION

Unbalance.—When an anchored mechanism is out of balance, either in oscillation about a point in a straight line or in rotation about an axis, external reaction or restraining forces are called into play to oppose the internal unbalanced or mass-acceleration forces. Since the surrounding bodies or foundations are not infinitely stiff, some oscillatory movement of the anchoring points is inevitable and this constitutes vibration. If the stiffness at the anchoring points is negligibly small, the unbalance forces are all available for shaking the mechanism. In general, the mechanical impedance of the anchoring points is complex and has to be taken into account, although, at particular frequencies, mass and stiffness reactances may nullify each other leaving only dissipative forces to constrain the system at these resonant frequencies. Unbalance forces usually have frequencies corresponding to the revolutions or oscillations per second of the system, or the low order harmonics, so usually they do not exceed 100 cycles per second.

Cyclical Irregularities.—In many mechanisms and machines the driving and load forces are not constant but are intermittent or change suddenly, as, for example, in piston engines, gears, pumps and electric motors. In rotating machines the frequencies of these cyclical irregularities are determined by the revolutions per second multiplied by the number of impulses per revolution, as, for example, in the cases quoted, the number of firing strokes, gear contacts, pump discharges and rotor slots. In the case of gears there are often other irregularities corresponding to the number of teeth on the table of the machine on which the gears were cut and in the case of alternating-current motors the slot note can be modulated by twice the supply frequency.

Rolling and Sliding Contact of Hard Surfaces.—Small irregularities in the surfaces of metals in unlubricated rolling or sliding contact give rise to appreciable vibration even when the surfaces appear to be relatively smooth to the touch. If, in the case of sliding contact, there is intermittent "stiction," or welding and tearing, known generally as "slip-stick," the ensuing vibration may have a pronounced frequency, like the squeak of a brake, determined largely by the friction, mass and stiffness of the parts in contact. Otherwise, the vibration is likely to contain all frequencies more or less equally, depending on any local accentuation by resonances.

Impacts.—A regular succession of impacts, such as is given by a pneumatic hammer or chipper, constitutes a vibration of a frequency corresponding to the number of impacts per second together with a train of harmonics due to its non-sinusoidal character. However, the impacts can shock-excite mechanical systems which are capable of vibrating, such as panels, at their natural frequencies, producing trains of damped oscillations and one of the harmonics may even excite part of the system to resonance, giving rise to an increased vibration of that frequency.

COMMON CAUSES OF NOISE

Vibrating Surfaces.—Any surface which is vibrating in a direction normal to its plane radiates sound waves of a frequency corresponding to that of the vibration. If the linear dimensions of the surface are large compared with the wavelength in air, $\lambda = \frac{1{,}100}{f}$ ft. or $\frac{33{,}400}{f}$ cm. where f is the frequency in cycles per sec. and all points on the surface are vibrating in phase, the air near the surface follows the movement of the surface and plane waves are radiated having a sound pressure $p = 42\,v$ dyne per sq. cm. where v is the oscillatory velocity of the air and surface in cm. per sec. The velocity corresponding to the reference pressure of 0·0002 dyne per sq. cm. is therefore 5×10^{-6} cm. or 2×10^{-6} in. approximately. Vibration amplitudes, velocities and accelerations corresponding to sound pressure levels of 0, 60 and 120 db under the above conditions of plane wave radiation are given in Table I. If the dimensions of the vibrating surface are small compared with a wavelength, and air circulation between front and back is prevented, for example, by enclosure, a frequency term enters into the expression for the radiation, and the sound pressure at a distance where the radiation has become spherical tends to follow the acceleration of the surface. If the area of the surface is A sq. cm., ρ the density of air = 0·0012 gramme per c.c., and x the distance in cm. from the surface where the radiation has become spherical, the sound pressure is:—

$$p = \rho \frac{vAf}{x} \text{ dyne per sq. cm.}$$

At distances intermediate between these two extreme cases, interference effects occur and each case needs individual consideration.

Sources of vibration have been discussed above.

Repeated Puffs of Gas.—Examples of pulsating air streams producing noise are to be found in fans, compressors and internal combustion engines. The oscillatory velocity of the air particles is often superimposed on the mean velocity of the air stream, but expressions similar to those quoted in the previous paragraph still give the sound pressure close to the source and at a distance x cm., large compared with the dimensions of the source in terms of the oscillatory component, v cm. per sec., of the velocity at the source and the area, A sq. cm., of the source.

High-Velocity Gas Streams.—Although a gas stream may not be obviously discontinuous it usually has turbulence and vortices which can be responsible for very loud noises. In free space, a vortex is a closed circulatory system but when it breaks on an obstacle pressure waves are produced. Trains of vortices at regular intervals can thus produce musical notes,[19] such as the Aeolean tones from telephone wires in a breeze, and turbulence can produce noises containing all frequencies, so-called "white noise," like the roar of a jet engine exhaust.

TABLE I.—Vibration Magnitudes

Corresponding sound pressure level, db	Oscillatory velocity, in. per sec. r.m.s.		Frequency, cycles per sec.				
			1	10	100	1,000	10,000
0	2×10^{-6}	Amplitude, in. ±	$4{\cdot}5 \times 10^{-7}$	$4{\cdot}5 \times 10^{-8}$	$4{\cdot}5 \times 10^{-9}$	$4{\cdot}5 \times 10^{-10}$	$4{\cdot}5 \times 10^{-11}$
		Acceleration, g ±	$4{\cdot}6 \times 10^{-6}$	$4{\cdot}6 \times 10^{-7}$	$4{\cdot}6 \times 10^{-8}$	$4{\cdot}6 \times 10^{-9}$	$4{\cdot}6 \times 10^{-10}$
60	2×10^{-3}	Amplitude, in. ±	$4{\cdot}5 \times 10^{-4}$	$4{\cdot}5 \times 10^{-5}$	$4{\cdot}5 \times 10^{-6}$	$4{\cdot}5 \times 10^{-7}$	$4{\cdot}5 \times 10^{-8}$
		Acceleration, g ±	$4{\cdot}6 \times 10^{-5}$	$4{\cdot}6 \times 10^{-4}$	$4{\cdot}6 \times 10^{-3}$	$4{\cdot}6 \times 10^{-2}$	$4{\cdot}6 \times 10^{-1}$
120	2	Amplitude, in. ±	$4{\cdot}5 \times 10^{-1}$	$4{\cdot}5 \times 10^{-2}$	$4{\cdot}5 \times 10^{-3}$	$4{\cdot}5 \times 10^{-4}$	$4{\cdot}5 \times 10^{-5}$
		Acceleration, g ±	$4{\cdot}6 \times 10^{-3}$	$4{\cdot}6 \times 10^{-2}$	4·6	46	460

REDUCTION OF VIBRATION AND NOISE

When it has been established that a machine is making too much vibration or noise it becomes necessary to consider the available remedial measures. The trouble may be due to some defect or bad design in the machine itself, or it may be due to some fault or lack of forethought in the installation. Both these possibilities must be given careful consideration to ensure that a result which is technically, economically, and, if necessary, aesthetically satisfactory is achieved.

Reduction at the Source.—The most helpful information in attacking the disturbance at its source is an analysis giving the frequency and magnitude of the components. This information is readily obtainable by means of a suitable transducer, amplifier and analyser as previously discussed. Components having definite frequencies can often be allocated to their respective sources from a knowledge of the mechanical or electrical particulars of the machine; with rotating machines, for example, dividing the frequencies of the components by the revolutions per second gives a series of numbers which may include the number of gear teeth, fan blades and armature slots, so giving positive identification of the sources of the respective components. Reduction of the fundamental rotational component is usually a matter for improved balance, and sensitive apparatus for detecting the magnitude and phase of residual unbalance has been described.[20] The ways in which gear errors, due to both the teeth of the cutting table and the profiles of the mating teeth, can be reduced by grinding, scraping and shaving, have been discussed[1, 21, 22] and substantial improvements have been effected in some cases. In particular, a resonance of the gear wheel has accentuated the tooth contact note at normal speed and necessitated a change to a different number of teeth.

It is often found that a substantial part of the noise or vibration of a gear consists of components which cannot be attributed to any particular feature of the gear, and of bands of frequencies so closely spaced as to be virtually unresolvable. Similar unrelated frequencies and bands are encountered in machines fitted with ball or roller bearings and it is felt that these two cases of gears and rolling bearings have a common feature of fundamental importance, namely, the contact of metal surfaces either rolling or sliding on each other. Even though these surfaces have been carefully ground, asperities of the order of 10^{-4} in. are inevitably present and will cause corresponding vibrations of the two surfaces relative to each other. Reference to Table I shows that such vibrations at medium and high frequencies can cause very loud noises. If, however, the two surfaces are separated by an oil film thicker than the asperities, solid contact is avoided and so is the relative vibration from this cause. It is difficult to guarantee the existence of such an oil film in the cases of gears and rolling bearings since the requisite conditions for hydrodynamic lubrication do not always exist there as they often do in the case of lubricated sleeve bearings. It has therefore been proposed to fill up the valleys

in the metal surfaces with "Teflon," but no information as to the success of this method is available. Where welding and tearing take place at the contact region, the extent to which the two metals alloy with each other is felt to be important. There is an obvious need for extensive investigational work in this field.

As mentioned above, some vibration and noise may arise from fans and electrical machinery and analyses will usually indicate the features responsible. In the case of fans, balance, blade design, clearance between runner and case and the excitation of natural modes of vibration of ducting by turbulence are all important factors and may need reconsideration. Appreciable improvements can be effected by damping the flat metal sheets forming air ducts so that their "ringing times" when impulse excited by turbulence are very much reduced. Two methods of achieving increased damping have been found effective. The first is to build the duct out of two-ply sheets of thinner gauge metal lightly fastened together by rivets and the second is to apply to the walls of the duct a layer of viscous material such as bituminised felt[23] or a resin-bonded compound[24] sprayed on to a thickness about twice that of the metal. In both cases, vibration of the sheet dissipates energy either in interlaminar friction or by viscous forces, so avoiding sustained vibrations which increase the noise in the air stream. The noise from the pulsating exhausts of internal-combustion engines can be reduced by smoothing out the pulsations and so making the exhaust gases into steady streams. This is effected by a low-pass filter consisting essentially of a receiver and an exhaust or "tail-pipe." The dimensions of the receiver and tail-pipe must be chosen so that the reactance of the former is much less than that of the latter at the frequency of the pulsations, the ratio of the two reactances being an indication of the attenuation. The reactance of a receiver of volume V ccs. at a frequency of f cycles per sec. is $X_v = \frac{\rho c^2}{2\pi f V}$ where ρ is the gas density in grammes per c.c. and c the velocity of sound in the gas in cm. per sec. The reactance X_l of a tail-pipe of length l cm., short compared with a wavelength, and cross section s sq. cm., is

$$X_l = \frac{2\pi f \rho l}{s}$$

If $X_l > X_v$ the attenuation is given by

$$A = \frac{X_l}{X_v} = \frac{4\pi^2 f^2 l V}{c^2 s}$$

or in decibels by 20 log A db.

This very much simplified theory of the single-stage silencer as fitted to automobiles is sufficient to indicate the roles played by the receiver and tail-pipe. In practice, receivers are often fitted with baffles to make multiple stage filters and alternative paths of different lengths are sometimes provided in attempts to achieve noise reduction by interference.

In electrical machines the slot note is usually the most important component in both vibration and noise. In direct-current machines it can be reduced by skewing armature slots, semi-closing them and grading air gaps, each of these three steps being capable of giving a reduction of 10 db or to roughly one-third amplitude. In alternating-current machines with distributed windings, the numbers of rotor and stator slots and the harmonics they introduce have to be carefully chosen[25] so as not to excite pronounced natural modes of vibration of the stator and frame. Owing to the complexities and uncertainties of the factors involved, it is often necessary to proceed step by step in the direction indicated by theory and to make an analysis at each stage to check the magnitude of the change effected and so to proceed with more certainty to the next step if further reduction is required.

INSTALLATION EFFECTS

In a great number of cases the vibration and noise of machines are needlessly increased by installation conditions. For example, machines with large oscillating or unbalanced rotating masses are often installed on the second or higher storeys of buildings with the result that excessive vibration is experienced throughout the building. In some cases the vibration is increased so as to be unbearable by resonance of the floor on which the machines stand. It is obviously better to install such machines on solid ground, preferably with an air gap several feet deep round the base. Alternatively, and, in difficult cases, in addition, the vibrating machine may be mounted on resilient supports which can be designed[1] to transmit only a fraction of the vibration to the building.

FOUNDATIONS

The use of a large foundation block resting on resilient mountings can reduce the vibration of a machine, or group of machines, by increasing the total connected mass. Such a block or steel frame is almost essential when supporting coupled machines resiliently as the group is then self-contained and free from relative movements. It is also very helpful with tall machines in that the base can be broadened, so reducing the tendency of the machine to rock on the resilient mountings. When a foundation block is sunk in the ground it is preferable to leave an air space all round the sides rather than to fill it with resilient material such as cork. It is also convenient to bring the mounting resilient material up to floor level rather than to have it under the block where replacement would be difficult. The block is then hung on cross beams passing through it near the top. This arrangement has the additional advantage that the centre of gravity of the supported system is usually approximately in the plane of suspension, thus leaving the vertical and rocking modes uncoupled. An excellent review of resilient mountings has been given by J. A. Macinante.[26]

Whenever resilient mountings are used it is important to ensure that their effectiveness is not materially reduced, or even cancelled, by solid connections such as pipes, cables, earth straps and holding-down bolts. The latter, if used, should have resilient washers and bushes, but in many cases holding-down bolts are not necessary or desirable. It has been shown[1, 27] that rubber is very suitable for resilient mountings and that some materials,[28] such as felt, are liable to have a very high ratio of dynamic-to-static stiffness and so to be correspondingly inefficient in attenuating vibration. A warning should also be given regarding the dynamic performance of leaf springs which, due to inter-lamina friction, have been known[29] to have a dynamic-static stiffness ratio of 30 for small amplitudes of vibration insufficient to cause sliding of the laminae. This trouble can be avoided by inserting thin sheets of soft rubber between laminae.

When noisy machinery is installed in the open air, it may be possible to take advantage of the attenuation of noise with distance. This attenuation is usually only a few decibels up to a distance roughly corresponding to the linear dimensions of the major noise-emitting surface or opening but thereafter it approximates to a reduction of 6 db for every doubling in distance. Inside an enclosure this attenuation with distance is limited by reflections from the walls which conserve the sound energy and cause an increase in sound level compared with free-space conditions. With hard bare walls this increase may amount to 5 or 10 db depending on the total sound absorption present. If, therefore, sound absorption is introduced into an enclosure the "build-up effect" may be reduced and the free space level approached. In both the above cases, by distance and absorption, the law of decreasing returns operates very quickly to limit the improvement that can be obtained in practice.

TRANSMISSIONS

Vibration of most building materials occurs with little attenuation so the vibration of machines in buildings should be prevented from reaching the structure. As indicated in the previous section, this can be done by using resilient mountings and by introducing discontinuities such as air gaps round foundation blocks and "breaks" of building felt round sections of concrete floors.

The reduction of air-borne sound in transmission is usually effected by some form of enclosure. If M lb. per sq. ft. is the surface density of the enclosing wall, the attenuation at a frequency of f cycles per sec. where the stiffness is negligible should theoretically be given by

$$\text{attentuation} = 20 \log Mf - 29 \text{ db.}$$

Investigations which were made at the N.P.L. have shown[30] that the values obtained in practice are somewhat lower, more realistic values being given by the relation

$$\text{attentuation} = 15 \log Mf - 21 \text{ db.}$$

Enclosures made of porous material, such as rock wool, can be used, but the attenuation in decibels is proportional to thickness and to get 30 db at medium frequencies calls for a thickness of the order of 1 ft.[31] and more at lower frequencies.

When the air-borne noise of a machine has been confined by a solid enclosure it becomes important to have the machine on resilient mountings, if not already so mounted, as otherwise the attenuation of the enclosure may be lost by conduction of vibration from the machine to the enclosure, from which it would be radiated as noise. The two attenuations of air-borne and structure-borne noise should be co-ordinated so as to avoid waste. The simplest enclosure is often a brick-walled concrete-roof type with no windows and a heavy door and such a construction can readily give attenuations of 30 db or more at medium and high frequencies. If it is essential to have windows, high attenuations can still be achieved[32] by making them of heavy plate glass and having two or more well spaced and separately mounted to avoid coupling. If lower attenuations are adequate, some form of steel framing filled in with panels of asbestos cement or similar material may provide a cheaper but effective alternative.[33] A little sound absorption inside is helpful but complete lining with sound-absorbing material is seldom justified.

As a result of enclosure it may be necessary to provide arrangements for cooling. If liquid cooling is used the liquid can be taken through flexible coupling pipes to the outside and cooled there, the flexible sections of pipe being necessary to avoid conduction of vibration to the enclosure. With air cooling, inlet and outlet ducts of adequate section must be provided and fitted with sound-attenuating systems to avoid the escape of too much noise. Data are available[34] for designing "splitter" type silencers to give any required attenuation of noise of specified frequency composition, provided that roughly half the duct cross-section can be sacrificed to be taken up by the splitters. This information is also available for designing silencers for any high-velocity gas streams, such as engine exhausts. If the frequency range is very wide, as in jet engines, there is much to be said for a two or more stage filter of the straight-through splitter type[35] which can be designed for low back-pressure.

GEARBOXES

A special case of enclosure is provided by gearboxes, although the principles involved are applicable to other cases of noisy machines coupled by shafts to other machines. The essential point is that the vibrations associated with the operation of gears are conducted both through the bearings to the case and through the shafts to other machines. It is therefore not sufficient to enclose the gearcase alone if quiet operation is essential. It is then necessary to interpose flexible couplings between the gear and other machines, preferably inside the noise reducing enclosure so that the only shafts coming out of the enclosure are relatively free from vibration. There are several ways in which this can be done[36] but it is difficult to avoid some increase in weight and dimensions as the price of reduced noise.

In order to demonstrate the substantial noise reductions which can be effected by this combination of resilient mounting and enclosure and

also to show the prime importance of dealing adequately with both these measures and the futility of dealing with only one, a small gear was enclosed within a steel gearbox. Flexible couplings were included in the input and output shafts and the gearbox was resiliently mounted inside the half-inch steel enclosure. Provision was made for short-circuiting the flexibility of the couplings and the resilience of the mountings, and also for quickly removing the ¼ in. thick steel cover of the enclosure. A driving motor and a generator were coupled to the input and output shafts and the load fixed at 1·25 kW. In view of the noise from the motor and generator, it was necessary to pick out the gear noise by an analyser, the principal components being the tooth contact note with its second and third harmonics. The results of the noise measurements are given in Table II, while the corresponding values of equivalent loudness of the gear noise as deduced from a loudness summation[11, 15, 37] of the three components are given in Table III. It is seen that, in this case, enclosure and resilience separately give reductions of only 3 or 5 phons but together they give 28 phons. The precise values will vary in different cases depending on the relative magnitudes of air-borne and structure-borne contributions to the noise, but it is clearly important to give adequate consideration to both in order to avoid disappointment and wasted effort.

TABLE II.—*Noise Analyses of Tooth Contact Components.* Microphone 18 in. from centre of gearbox. Input 1·25 kW. I.L. — Intensity level db.

Frequency, cycles per sec	A Solid with cover off, I.L.db.	B Solid with cover on, I.L. db.	C Resilient with cover off, I.L. db.	D Resilient with cover on, I.L. db.	Component
1,100	85	84	76	49	Tooth contact Fundamental
2,200	80	76	77	50	2nd harmonic
3,300	82	65	70	44*	3rd harmonic

* Background

TABLE III.—*Loudness Summation of Tooth Contact Components, Equivalent Loudness (Phons).*

A Solid with cover off, E.L. Phons	B Solid with cover on, E.L. Phons	C Resilient with cover off, E.L. Phons	D Resilient with cover on, E.L. Phons
91	87·5	87	63

CONCLUSIONS

It has been shown that the solution of problems involving the reduction of noise and vibration of mechanisms and machines calls for a broad appraisal of the factors contributing to the disturbance and a critical assessment from the utilitarian, economic and aesthetic points of view of the various methods available for effecting improvements. In some cases changes in design or materials may be indicated but in others the use of a standard machine together with adequate measures to localise the disturbance may be a better all-round solution. An important gap in the present fundamental knowledge of the generation of vibration concerns the rolling and sliding contact of hard metals and as this problem concerns such important mechanisms as ball bearings and gears, it calls for urgent consideration on the part of competent research organisations.

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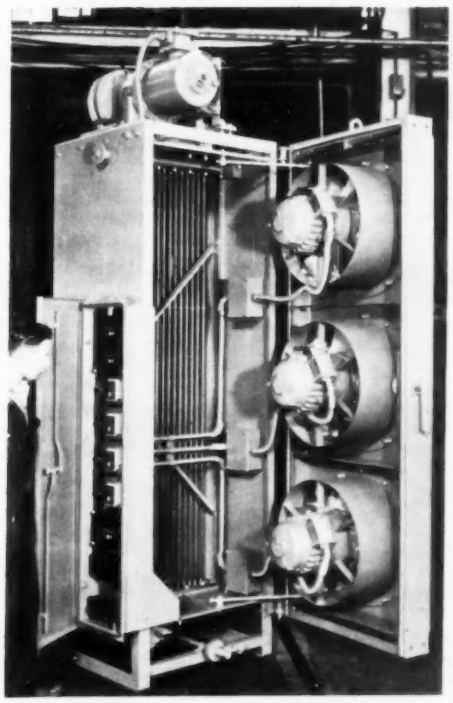
SPACE-SAVING TRANSFORMER COOLER

The accompanying illustration shows a forced-oil air-blast cooler for transformers, which has been developed by the British Thomson-Houston Company, Limited, Rugby, for use on sites where it is desirable that the space occupied should be reduced to a minimum. It is intended for mounting directly on the end or side of the tank and has the advantage that in many cases it will be possible to dispatch both transformer and cooler as a factory-assembled unit, thereby reducing erection work on site.



New B.T.H. forced-oil air-blast cooler for power transformers, showing the internal arrangements.

The equipment consists essentially of a sheet-steel cubicle containing the cooling elements of non-ferrous metal (which are not therefore subject to rust). Three fans, which have been designed to reduce windage noise to a minimum, are mounted on the door of this cubicle and the control gear is, as will be seen, contained in a separate built-in compartment.

The prototype model has three two-speed fans, which are electrically driven by 3 kW and 5 kW motors as necessary and a single-speed oil pump, which is driven by an oil-immersed motor. The present motors enable cooler ratings of 70 kW and 100 kW to be obtained, but further developments envisage the use of a change-pole pump motor to give ratings of 50 kW and 100 kW, with total power inputs of 1½ kW and 5 kW, respectively.

In practice, this dual rating will enable the fan motors to be run continuously at half speed when the transformer is lightly loaded, thus overcoming the condensation difficulties which occur with conventional cooling arrangements during idle and cold periods.

Each fan motor is separately protected so that should one be out of service the operation of the other two is unaffected. A complete set of control apparatus is provided and when two or more cooler equipments are fitted to a transformer these can be grouped in one cabinet together with other auxiliary services.

The present cooler is designed to dissipate 100 kW with a maximum temperature rise of 40 deg. C. above ambient. A single unit will thus be suitable for transformer ratings up to about 15 MVA, although two or more can be used in parallel on the larger sizes.

Book Reviews

WHO SHOULD CONTROL MATERIALS?

The Specification and Management of Materials in Industry. By C. H. STARR. *Thames and Hudson, Limited*, 30 *Bloomsbury-street, London, W.C.*1. (21*s.*)

Although the main preoccupation of British industry is with the conversion of materials from simple forms to higher or more complex forms of greater utility, too little attention is paid to the influence of those materials on the manufacturing cycle. Concentration upon productivity as the measure of efficiency has directed attention to the time spent in producing an article, rather than to the overall suitability of the end product, and still less to the effect upon overhead costs of materials which require additional operations in processing, or which, through unsuitability for the purpose, cause additional difficulties during manufacture.

Notably in the fields of light high-speed transport—aircraft, aircraft engines, motor cars, lorries and Diesel locomotives—there has been a realisation that materials play a most important part. By increasing the working stresses by the use of stronger and better materials, savings in weight have been achieved which have given important competitive and financial advantages. The firms making these products have had at their disposal designers and engineers capable of understanding the functioning and use of their product, as well as the capabilities of the materials used. To obtain consistency and reliability at the high working stresses, it will have been necessary to obtain precise information regarding the operating loads, to specify the materials carefully, and to take all necessary steps to ensure that the material supplied conforms to its specification.

In cases such as these, the cost of the effort to develop and control the material is far outweighed by the return, which may be in enhanced performance and hence value to the customer, or in reduced manufacturing cost due to the smaller amount of material required. These advantages, together with the concentration upon manufacturing methods, may tend to mask the influence of the material itself upon the cost of production. In some cases the choice of material may be determined by the over-riding need for certain physical properties, as in the case of gas-turbine blades, so that the difficulties of machining and processing are unavoidable. In applications where duties are lower there is greater freedom of choice, and the influence of the material upon manufacturing and processing costs can then receive greater consideration.

In all cases, however, there is too seldom any deliberate effort to look upon materials as being worthy subjects for study by management. Mr. Starr's book makes a praiseworthy attempt to bring this shortcoming to the notice of those in what he calls "general light engineering" who have presumably given less thought to the subject than have managers in other industries. What he has to say will be of value to all who are concerned with the working of materials.

Although the subject has been dealt with, effectively but somewhat summarily, in a number of American books on management and industrial organisation, and in handbooks of production and quality control, the work under review is probably the first one in its class to deal with the matter at such length. Any shortcomings which the book possesses are due to the author's attempts to plough a straight furrow through virgin soil, and should therefore be viewed sympathetically. As a pioneer, too, he has only his own experience to draw upon, and in consequence his suggestions may need some modification to meet particular cases.

Pointing out that materials have been neglected in his own industry, which would appear to be concerned with light electrical components, Mr. Starr is at some pains to justify the appointment of a Central Materials Authority. This department is to be responsible for all problems arising in connection with the use and handling of materials. Ideally, it is in charge of an engineer, who "should be an experienced mechanical or electrical engineer, thoroughly familiar with the company's policies and products. He should have a good deal of the outlook of a production engineer, must certainly possess qualities of leadership, and last but not least, should have some understanding of the purposes and principles of management." In addition, he is to control a senior man with commercial ability, a metallurgist, a physicist, a chemist, and a laboratory staff which is separate from the chemical laboratory that presumably exists already.

Such a policy of perfection will certainly be difficult to apply in most cases, although few executives would hesitate to introduce into their organisation such a paragon of virtues if he came within their grasp, even though the author has omitted to specify a knowledge of design and stressing which is really essential for the full exercise of his function. In the majority of cases, however, and especially in the firm of "some thousands" which is the pattern, the organisation will already be well established. In such cases there is little doubt that the appointment of a senior engineer capable of studying materials along the lines indicated would still be amply justified, although his precise title and position in the organisation would need to be adjusted to the conditions of the case.

Mr. Starr recommends that the central materials authority should come under the chief engineer or the chief designer. Many production executives will quarrel with this, more especially in those larger firms where the current tendency to specialisation is making the design department increasingly remote from manufacture, and the production department increasingly dependent upon itself for the solution of problems arising with new materials. Indeed, from the number of practical examples of difficulties encountered and overcome, which are given in the book, the bias is in fact towards production planning, and it is probably in this department that Mr. Starr's authority will eventually find itself.

The book should be read especially by the young engineer who wishes to enter what can be a fascinating branch of the profession. He will find many examples which will help him to develop the correct approach to the problem as a whole. He will also find the book liberally sprinkled with home-truths with which no engineer will disagree. The production executive, however, will feel that the present subject matter could well have been condensed, to allow mention of such important aspects of materials management as stock control, scrap segregation and scrap recovery, safeguards against the mixing of materials, inspection, non-destructive testing, the study of production variables and the establishment of minimum standards of acceptance.

The chapters on specifications are useful, but anyone faced with the task of writing specifications *ab initio* would be well advised to refer as well to the more professional works which have emerged from the pens of American professors and consultants, who somehow find so much more time to write for the guidance of their fellow men. It is to be hoped that Mr. Starr will some day be able to find time to produce a second edition of his book, revised, condensed and amplified to meet the need for a more general work applicable to industry as a whole. Probably no firm in this country would not benefit in some degree by a review of its materials in the light of the ideas suggested by this book.

FLIGHT OF FANCY

Space Research and Exploration. Edited by D. R. BATES and PATRICK MOORE. *Eyre and Spottiswoode (Publishers), Limited*, 15 *Bedford-street, Strand, London, W.C.*2. (25*s.*)

Something like 20 years ago, the British Interplanetary Society was formed by a few people who were content to be considered complete cranks by the vast majority of their fellow-men. This opinion persisted for many many years but some men in this country, in America and in Germany who believed that one day man would reach the moon went on with their experiments and their researches and put their theories and results down on paper. It took a second world war to make people realise that in the V.2 the Germans, at least, had something.

Now, with Government backing, scientific societies' approvals and the International Geophysical Year, interplanetation has suddenly become respectable. It is the subject of journalistic leaders as well as comic strips; of erudite papers as well as children's books. The difficulty is that the little band of believers have made such strides that the "average man" has not much chance of finding out how it all started. *Space Research and Exploration* attempts to fill this gap in our education by taking the reader gently by the hand through a simple first two chapters of "Introduction" and "History" and gradually breaking him in to the more advanced stuff of propellants for rockets before dissuading him from taking a ticket, with chapters on the risks and difficulties attendant on this interplanetary business.

It is a book "written for the general reader by a panel of scientists" and it succeeds in being as simple as such a book could be. Certainly it covers every aspect one could require to take an intelligent interest in what may, one day, be the biggest step (forward or backward?) that exploring man can take.

The contributors form, perhaps, the most authoritative panel this country can produce. Seventeen appendices of informative detail round off a well-conceived and absorbing book which should go far to show that planetary aspiration should not, much longer, be a flight of fancy.

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NEW BOOKS

Plant and Process Dynamic Characteristics. Proceedings of a Conference held at Cambridge, April 4-6, 1956, by The Society of Instrument Technology. *Academic Press Incorporated*, 111 *Fifth-avenue, New York* 3, *N.Y., U.S.A.* (8.80 *dols.*); *and Butterworths Scientific Publications*, 88 *Kingsway, London, W.C.*2. (50*s.*)

The papers contained in this volume are the results of the first attempts in Great Britain to bring together for discussion those engaged in fundamental research on the dynamics of processes, those who specialise in measurements, and those with practical experience of plant operation. Contributions have been invited from persons actively engaged in these fields who could report on new concepts, techniques or results. There is therefore no systematic survey of the field and the proceedings are in fact biased in the direction of chemical engineering.

Pocket Book for Mechanical Engineers. By D. A. Low. New edition (1956) revised by BEVIS BRUNEL Low. *Longmans, Green and Company, Limited*, 6 and 7 *Clifford-street, London, W.*1. (21*s.*)

It is nearly 60 years since D. A. Low's Pocket Book for Mechanical Engineers first appeared. This, the latest edition, has been revised in accordance with the revision of certain British standards, particularly regarding iron and steel, non-ferrous metal alloys, wood, Unified screw threads and the like.

Electronic Computers: Principles and Applications. Edited by T. E. IVALL. *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.*1. (25*s.*)

A non-mathematical introduction to the principles and applications of computers employing valves and other electronic devices that is written chiefly for

readers with a knowledge of electronics. However, certain chapters are suitable for reading by business executives. Both digital and analogue types are described and applications are outlined. Much of the book is devoted to describing circuitry and construction. The book is written for the non-specialist and avoids complex mathematics.

Television Engineering, Principles and Practice. Volume 3: Waveform Generation. By S. W. AMOS and D. C. BIRKINSHAW. *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.*1. (30*s.*)

The third volume of a text-book on television engineering, this work is written by members of the B.B.C. engineering division. It is primarily for the instruction of the Corporation's own staff, but as the book is intended to be a comprehensive survey of modern principles and practice it is of general interest. This volume gives the application in television of sinusoidal, rectangular, sawtooth and parabolic waves. The main body of the text is devoted to the fundamental principles of the circuits commonly used to generate such signals, the treatment being largely descriptive in nature and consequently less mathematical than the previous volume.

Principles of Turbomachinery. By D. G. SHEPHERD. *The Macmillan Company, 60 Fifth-avenue, New York* 11, *N.Y., U.S.A.* (10 dols.); and *The Macmillan Company (New York), 10 South Audley-street, London, W.*1. (56*s.*)

The book is intended to correlate the existing detail treatment of turbomachinery, and represents the culmination of a series of notes used in a course for mechanical engineers. The scope has been designed with two objectives, the first being a general treatment of all forms of turbomachines and the second the application of these principles to the several kinds of pump, compressor and turbine in sufficient detail to allow the major design and performance factors to be appreciated. No attempt has been made to introduce design from the mechanical standpoint, except to point out where such considerations circumscribe the fluid energy design.

Chemical Service in Defence of the Realm. By W. G. NORRIS. *Ministry of Supply, Chemical Inspectorate, Station Approach Buildings, Kidbrooke, London, S.E.*3.

The Chemical Inspectorate was formed in 1854 as a small testing unit of the War Office and is one of the oldest scientific establishments of the Government. The first head of the Inspectorate, then installed in one of the old gun factories at the Royal Arsenal, Woolwich, was Sir Frederick Augustus Abel, Bt., F.R.S. Given the title of War Department Chemist, he established a tradition of research and development which flourishes to-day. The present illustrated booklet of 91 pages traces the history of the Inspectorate from its small beginnings to the present day, when " its responsibilities embrace over 2,000 Service stores—from grenades to ground sheets."

Finishing Handbook and Directory, 1957. Edited by I. S. HALLOWS. *Sawell Publications, Limited, 4 Ludgate-circus, London, E.C.*4. (37*s.* 6*d.*)

The seventh edition of this *Handbook and Directory* has undergone a number of changes but the layout is broadly similar to the last edition. The work is divided into two parts. The first, printed on white paper, discusses in some detail the various finishing procedures available, such as spray painting, stove enamelling, electroplating, anodising, galvanising and vitreous enamelling. The second part, printed on buff paper and thumb-indexed, consists of classified lists of British suppliers of finishing equipment, plant and materials and also of jobbing firms in these industries. Additions to the first part include new data on degreasing, paint application, and vitreous enamelling methods, and the treatment of electroplating wastes.

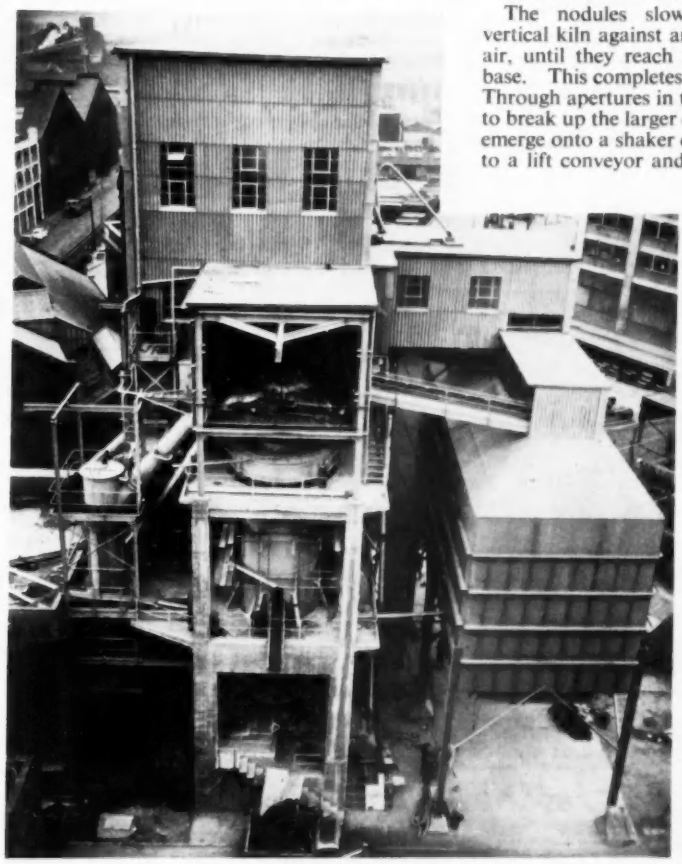
Handbook of Industrial Electronic Control Circuits. By JOHN MARKUS and VIN ZELUFF. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York* 36, *N.Y., U.S.A.* (8.75 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.*4. (66*s.*)

This book is a companion to the *Handbook of Industrial and Electronic Circuits* and the treatment is similar. Industrial electronic circuits issued in the magazine *Electronics* during the period 1948-55 are published and arranged for quick reference. The circuits are grouped in chapters according to function, and an index is provided in which cross-indexing has been widely used to enable a specific circuit in the book to be located when it is known under a variety of names. Included with each circuit are concise descriptions of the general nature of the circuit, the values of important components and a reference to the original source.

BUILDING WITH FLY-ASH

AGGREGATE PLANT AT BATTERSEA POWER STATION

One of the problems of modern power station operation is the disposal of fly ash which is produced in quantity, particularly from pulverised fuel firing and when low grade coals are used. A plant has now been built at the Battersea power station by Sinterlite Limited, 2 Caxton-street, London, W.1, and the Cementation Company, Limited, 20 Albert-embankment, London, S.E.11, by which the fly-ash can be converted to an aggregate for making building blocks. The output of fly-ash from Battersea alone is of the order of 150-160 tons a day as recovered from the precipitation equipment. With the new plant it is anticipated that the whole amount will be converted to a saleable product, instead of having to be disposed of by dumping in some convenient spot (a costly process). It is claimed that this is the first plant of its type in the world.



Fly-ash pellets fall into the vertical kiln and are sintered to form an aggregate. The resultant material (from ¼ in. diameter downwards) is graded into the three hoppers on the right. There is a second kiln on the far side of the building.

At Battersea the ash is conveyed pneumatically from the precipitators to a large central hopper in the Terlite plant. The first operation is to coagulate the ash into small nodules, and this is done by first adding a little water to it in paddle mixers and then passing the resultant paste by screw conveyors into a rotating bowl with an inclined axis. As the damp mix goes round within the bowl, nodules are formed, which, ideally, are about ⅜ in. diameter. The nodules spill from the edge of the bowl, and fall into the mouth of a kiln, shown in the illustration, under construction. In this they are burned and the sintering process renders them hard. Subsequently the material passes through crushing rolls to ensure that the size does not exceed ¾ in. diameter, and it is graded into three sizes. Any powder formed during the process is recirculated back to a separate chamber contained in the supply hopper. Combustion is maintained within the kiln by the fact that the nodules contain some five per cent. of carbon. It would actually be possible to maintain combustion at 2½ per cent. carbon, and consequently the excess heat has to be removed. The hot gases are drawn off from the top of the kiln, and passed to water coolers where the heat is dissipated and at the moment, wasted. The temperature attained within the kiln is about 1,300 deg. C.

The nodules slowly descend through the vertical kiln against an upcoming stream of cold air, until they reach the revolving grate at the base. This completes one revolution in an hour. Through apertures in the grate, which is designed to break up the larger clusters, the sintered pellets emerge onto a shaker conveyor which takes them to a lift conveyor and so to the grading screens of the three delivery hoppers. The three sizes at present in use are from ¼ in. to ⅜ in., from ⅜ in. to ⅛ in. and from ⅛ in. downwards. Everything smaller than 100 mesh is returned to the surge hopper. After the supply hopper the plant is duplicated, there being two sets of pelletisers and kilns; each set is capable of handling 150 tons a day. Automatic control equipment is being fitted so that the level of the material in the kiln will govern the speed of operation of the mixer, and also the speeds of the various conveyors. It is expected that when the preliminary runs have been completed, the plant will be operated by one man only.

The various moving parts of the plant are driven by electric motors as also is the compressed air plant for supplying the kilns and the process controllers. Fitted below the revolving grate are two sets of doors which act as an air lock so that pressure can be maintained. The water for cooling the exhaust gases is obtained from the Thames to which it is returned after circulation.

The density of the final pellets is approximately 50 lb. per cub. ft., and blocks made from it have a high crushing strength. It is very much lighter than stone aggregate. A mix giving a density of 68 lb. per cub. ft. has a 600 lb. per sq. in. crushing strength, and a concrete 3-2-1 graded mix with a density of 92 lb. per cub. ft. would have a crushing strength of approximately 3,000 lb. per sq. in. The material is inert, and is free from combustible or sulphurous matter. The heat conductivity of blocks is about one-quarter that of traditional concrete, and Terlite is unaffected by an oxy-acetylene torch except at the actual point of application. A high degree of noise insulation can also be obtained. Apart from building blocks, it can also be used for road surfacing and similar applications. Future development programmes include research work on the extraction of iron and germanium from the fly-ash prior to the sintering process.

NUMERICALLY-CONTROLLED MILLING

MACHINE AND CONTROL SYSTEM DESIGNED AS A UNIT

The control of machine tools by means of a punched tape, which carries the required information in the form of coded numbers, is not new, but a machine now in use in the United States is claimed to be the first to be designed to work specifically in this manner. It has been built to specifications drawn up by the user, the Martin Company, Baltimore, the electronic control equipment being made by the Bendix Aviation Corporation, and the machine itself, a horizontal-spindle miller, by the Kearney and Trecker Company, Milwaukee.

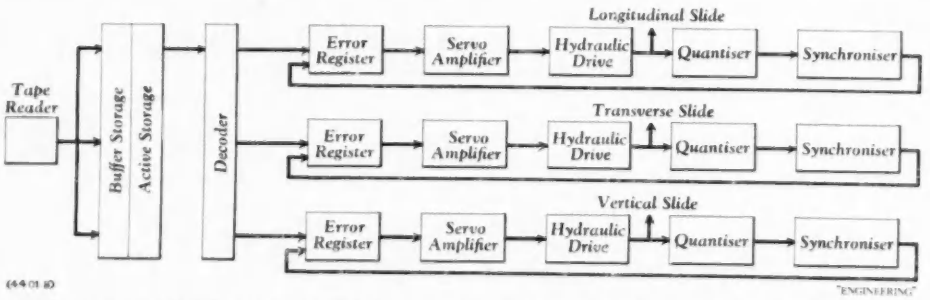
Components to be machined are mounted in a special fixture on a vertical angle plate on the machine table; the angle plate has a working surface of 48 in. by 144 in. Longitudinal travel of the table is 120 in., vertical spindle travel 48 in., and transverse travel of head 28 in. The spindle is driven by a 20 h.p. motor, and speeds vary from 36 to 800 r.p.m. Feed rate varies from 0 to 50 in. per minute, and there is a rapid traverse of 120 in. per minute.

CONVERTING TO NUMBERS

The first step in the sequence of operations is to convert the orthodox drawing of the component to be machined into a special type of numerical drawing. On this all dimensions are given either perpendicular to or parallel with a pre-determined reference point, and the drawing thus describes the component mathematically in relation to this reference point. All the dimensions are indicated by symbols in the field of the drawing, and these dimensions, together with other machining data, are tabulated on the numerical drawing. This information, together with feed rates, cutter radii, special instructions to the computer, and special instructions to the milling machine, is then entered by hand on a process planning sheet.

Punched tape, prepared by an electronic computer from information based on a special drawing, controls this milling machine three-dimensionally.

While this work is in progress a special holding fixture is designed. This is so arranged that the locating surfaces of the component always align in the same relative position to the reference point designated on the fixture. The clamps, locating surfaces and reference point are co-ordinated with the process planning sheet. This sheet is then sent on for the next operation, the preparation of a punched paper tape on a "Flexo-writer." This machine, which resembles a type-writer, and is used similarly, produces a punched paper tape, together with a type-written sheet. The latter can be compared with the process planning sheet for checking purposes. The paper tape is used as the input of a computer, which calculates the necessary machine control commands, and puts them on a plastic tape in the form of punched holes. This tape is then used for automatic control of the milling machine.



A plastic tape, with information in coded form, is "read" by a photo-electric cell. The sequence of operations which follows is shown diagrammatically above.

Tape Reader.—A photo-electric reader is employed to sense the holes in the tape.
Buffer Storage.—Receives one block of information from the control tape and stores it until required by the active storage section.
Active Storage.—Receives information from buffer storage and supplies it to the decoder as required.
Decoder.—Changes coded digital information on control tape to command pulses which serve as input to the machine-motion servos.
Error Register.—Keeps a running count of difference between the number of command pulses from the decoder and the number of feedback pulses from the quantiser on the machine. The error count is then converted to a proportional voltage.
Servo-Amplifier.—Receives and amplifies the proportional voltage from the error register. Its output drives the torque motor of the hydraulic servo valve.
Hydraulic Drive.—Each drive consists of a rotary hydraulic motor coupled to a lead screw through a low backlash gear train. The lead screw drives the table, carriage or spindle by means of a ball bearing nut.
Quantiser.—Each axis has geared to it a quantiser which produces electrical signals as the axis moves.
Synchroniser.—Converts the signals from a quantiser into pulses—one pulse for each increment of travel. These pulses represent a feedback of motion which has taken place.

NUMBERS TO PUNCHED HOLES

The basic machine unit of movement is 0·0002 in. The computer equipment calculates the path which the tool must follow to produce the desired component form, and punches this information on the plastic tape in the form of a binary code based on the number of machine units in each required machine motion. Thus, if a movement of 0·1532 in. is needed, this will involve 766 machine units of 0·0002 in. This figure, 766, is punched on the tape in the code, which is simply a description of the number using a series of ones and zeros.

When the tape has been prepared it is placed in the machine control unit. The operator then selects the spindle speed, as indicated on his instruction card, centres the spindle over the reference point, and presses the button for tape control. All operations, except cutter-changing, are then completely automatic.

PUNCHED HOLES TO MACHINE MOVEMENTS

Movements of the machine table and spindle are hydraulic, under the control of the machine electronic unit, which takes its instructions from the tape. The holes in the tape are sensed by a photo-electric reader, and this information, after passing through storage units which issue it as required, is de-coded and converted to command pulses, which serve as input to the machine motion servo-mechanisms. The accompanying diagram shows the layout of the machine control unit in more detail.

Many advantages are claimed for punched-tape control, and the system, properly applied, has obvious applications in addition to those in the aircraft industry, for which the present equipment was designed. Among the advantages of the system are the fact that tapes can be produced much faster and cheaper than models or cams, tooling costs are reduced, and tool life should be increased as a result of automatic control of feed rates. Reduction of operator fatigue results in a lessening of scrap, and safety benefits from the same cause. In the case of the component itself, better and more consistent finishes and dimensional accuracy are obvious consequences of automatic control, and it becomes possible to effect weight savings by designing and dimensioning to minimum tolerances, which can be easily held because of the intrinsic accuracy of the process.

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ANTI-VIBRATION SEALANT

In very many applications, nuts or bolts have to be locked against vibration. A liquid for the purpose is now being marketed by Douglas Kane Limited, 5 New Quebec-street, London, W.1., which is known as Loctite. It is a product of American Sealants of Hartford, Connecticut, United States. The liquid is run on to the bolt to be sealed and penetrates into the spaces between the seating threads where it sets as a tough plastics material. Any which inadvertently spills on exposed metal surfaces remains liquid and can be wiped off, as the hardening depends on two factors. These are first the catalytic effect of the surfaces and second, the exclusion of air. In the presence of air the material remains liquid.

It is claimed that 10 c.c. of the liquid will treat 700 ¼ in. nuts and bolts, and two grades are available for coarse threads and loose fits, and fine threads and tight fits. Other grades give stronger or weaker bonds. The sealant hardens quickly, and a breaking torque of 65 per cent. of the final value is reached in 12 hours and 85 per cent. in 24 hours. Hardening is complete in 15 minutes if the temperature is raised to 212 deg. F., and in 2 minutes at 250 deg. F. It is claimed that the material is resistant to vibration, but that the bonding can be broken by the use of ordinary tools.

CHECKING COLOUR TELEVISION SIGNALS

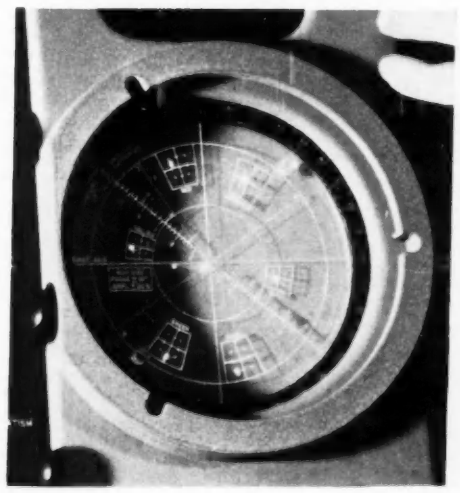
In colour television, hues and patterns are represented by electrical waveforms. As such they may be readily transmitted from place to place. When equipment is being tested it is important to ensure that the translation from colour values to electrical waveforms is occurring correctly. If a standard pattern is used for test purposes, a standard electrical waveform should be obtained. However, the waveforms of colour television are of some complexity and their examination is no easy matter.

Recognising the need for specialist equipment in this field, Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex, have produced an instrument known as the vectorscope. By use of it, signals in various parts of television equipment can be checked for conformity with the standard required. Such checking would generally be done with the camera focused on a standard test card. However, the system having been aligned correctly, it is then possible to use the vectorscope to analyse the colour content of any scene that faces the camera. Thus the producer is presented with an aid to establishing a balanced colour composition for his picture.

The display of the vectorscope is a cathode-ray tube. The radial distance of the spot from the centre of the tube face represents the degree of colour saturation. The angle between the radius to the spot and a fixed radius on the screen represents the hue. When used in conjunction with the colour bar test signal, the vectorscope produces a pattern of bright dots corresponding to the tips of the various colour vectors, and a pattern of lines corresponding to the transitions between colours. As shown in the illustration, " boxes " indicating tolerances and limits are drawn on a transparent scale, superimposed on the tube, to provide a convenient indication of the quality of the signal. However, the tolerances only refer to the colour information since the instrument does not consider the luminance signal.

In the N.T.S.C. system, the chrominance information is impressed on a sub-carrier which is modulated in amplitude, in proportion to the colour saturation, and in phase, in proportion to the hue. The vectorscope employs a pair of quadrature demodulators similar to those used in colour monitors and receivers, and a burst-controlled oscillator for deriving the reference sub-carrier from the colour synchronising bursts contained in the signal under test. The outputs of the two demodulators are applied, after suitable filtering and amplification, to the horizontal and vertical plates of the cathode-ray tube.

The quality of a colour television waveform can be measured with the vectorscope. It is also useful as an aid to obtaining balanced colour composition. Shown below is an enlarged view of the transparent scale superimposed on the tube.



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MACHINING SMALL COMMUTATORS

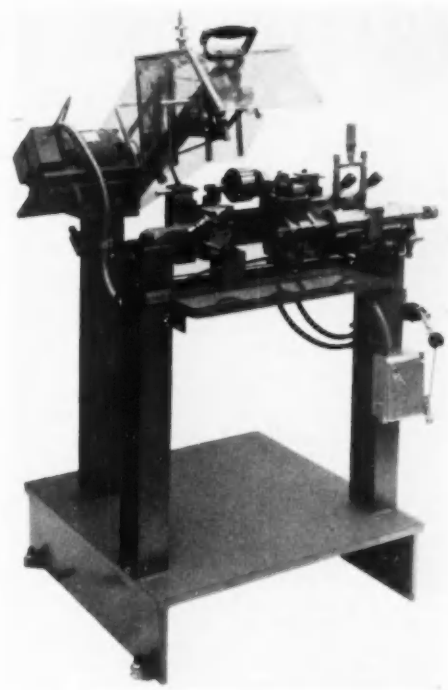
The speedy machining of motor commutators can be a very great advantage when motors are mass produced. A lathe designed for this specific purpose has been produced by Small Electric Motors, Limited, Eagle Works, Churchfield-road, Beckenham, Kent, and was displayed at the recent Electrical Engineers Exhibition. It is shown in the accompanying illustration.

Concentricity is ensured as the armature revolves on its own spindle, and quick loading is achieved by mounting the spindle in V-blocks. The armature is rotated by a flat belt which bears against the segments when the cover guard is lowered. Once the driving motor is started the guard is locked in position and cannot be released until the end of the cut, or until the motor is stopped by the hand control.

When the armature has been loaded into the V-blocks (which are faced with tungsten carbide to reduce wear), the cycle is started by lowering the guard. This engages the belt drive and automatically starts the driving motor. At the same time, the air-hydraulic system comes into action to feed the cutting tool along the commutator. The rate of feed is infinitely variable. When a pass of the commutator face has been made, the tool is automatically returned to its starting point, the motor is switched off, an electromagnetic brake applied, and the interlock on the cover guard released. The guard can then be lifted by releasing the hand catch and a fresh armature exchanged for the machined one.

At the end of each cut the tool automatically retracts for the return stroke, and this can be made to occur at either end by moving a knurled washer. Thus, cuts can be made in either direction. The commutator size is maintained automatically, but the tool can be advanced slightly for undersized specimens by moving a hand lever. Provision is made for accurate tool setting and for quick adjustment of the two V-blocks to allow for different journal diameters. In addition to the automatic controls, an isolating switch gives immediate reversal of the tool motor, or immediate stop and isolation of air and electric power.

The V-blocks will take journals up to $\frac{27}{32}$ in. in diameter and with a shoulder length not exceeding 17 in.; the blocks are adjustable both with respect to each other and to the commutator position. The maximum face length of commutator that can be machined is $1\frac{1}{2}$ in. and the standard model will take rotors with a maximum diameter of 4 in. Either tungsten carbide or diamond tools can be used. The air pressure required is between 40 and 50 lb. per sq. in.



Speed and simplicity are the aims of this lathe for machining small commutators.

and can be obtained from standard high pressure lines by the use of a reducing valve; this arrangement also smoothes out pressure fluctuations and ensures an even feed. Working at the normal cutting speed of 800 ft. per min., a complete cycle varies from 5 to 20 seconds according to the length of cut and allowing for loading and unloading.

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AUTOMATIC SCRAP BALING

What is claimed to be the largest scrap baling press in this country is now at work at the Steel, Peech and Tozer works, Rotherham, of the United Steel Companies, Limited. Supplied by Lindemann Maschinenfabrik, G.m.b.H., Düsseldorf, W. Germany, the machine will deal with 3,500 tons of iron and steel scrap a week, compressing it into bales 3 ft. by 2 ft. by 4 or 5 ft., the latter dimension varying according to the type of scrap being handled. A bale of these dimensions weighs up to 2 tons and fits easily into an open-hearth furnace charging pan. It compares most favourably with the load of 4 to 6 cwt. which is all the pans will take when loose scrap is charged.

The machine has a rectangular cast steel press box, into which scrap is fed from a tilting hopper. When the scrap has been charged, the hydraulically-operated lid of the press box closes, effecting the first compression. Then two half-pressure rams exert lateral pressure on the partly-formed bale, and finally, it is compressed longitudinally by a high-pressure ram set at right-angles to the half-pressure rams. The finished bale is ejected through a slide in the wall of the press box on to a conveyor. From this point it can be sent direct to the melting shop or to stock as required.

The complete operation, which is fully automatic, takes $3\frac{1}{2}$ minutes, and during this time the hopper is re-filled by magnet crane ready for the next baling cycle. Two multi-stage hydraulic pumps, each driven by a 140 h.p. motor, and housed in a new building adjacent to the baling press, provide the necessary power. They incorporate automatic cut-offs for the different pressure stages, and are under the control of a central electro-hydraulic valve. Auxiliary control is provided in the operator's cabin for use in emergency.

FRAMEWORK FOR STUDYING NUCLEAR FUELS

BUILDING THE DOUNREAY ATOMIC ENERGY ESTABLISHMENT

Concluded from page 668

A successful atomic power programme depends on the efficient and economic use of nuclear fuels. With this in mind, the Industrial Group of the United Kingdom Atomic Energy Authority have set up a research establishment at Dounreay in the north of Scotland, where facilities for experimental work are in process of construction. These facilities will include a fast breeder reactor (which may lead the way to a more thorough use of the energy potential of nuclear fuels); a materials testing reactor (in which the optimum form and composition of fuel elements and their protective cans will be determined); chemical processing plant (in which separation of unburnt fuel and fission products will be carried out); and fuel-fabrication plant (in which the fuel elements will be assembled ready for use in a reactor). Fuel processing, which represents a significant fraction, if not the major part, of ultimate fuel costs, will be studied in the establishment's laboratories, several of which are now under construction. In the present article descriptions are given of the various premises and installations at Dounreay, with special reference to the contributions made by contractors. The first part of the article published on May 24 (page 665) was devoted to the fast breeder reactor, while an introductory article, which appeared on May 17 (page 610) presented a survey of the work to be undertaken by the establishment, a general description of the fast breeder reactor and a summary of some of the nuclear principles involved. The article continues with a discussion of construction work at Dounreay, the special nature of which is indicated by Fig. 14. The range of plant to be constructed may be gathered from Fig. 15, which shows the fuel-processing cycles for the fast and materials-testing reactors. In addition, there are various laboratories and other experimental facilities.

2—Construction Requirements

The Dounreay site which occupies a former Naval airfield is generally flat with a slight northward slope towards the sea coast which is immediately adjacent. The buildings required may be divided into four principle groups, associated with (1) the fast reactor, (2) the materials testing reactor, (3) chemical processing, and (4) administration and services. These will be discussed under separate headings.

From the viewpoint of bearing pressure there were virtually no foundation problems, since immediately below a thin layer of top soil and disintegrated rock, in total rarely more than 3 ft. thick, was encountered the top surface of a deep stratum of Caithness sandstone. One aspect which had constantly to be kept in mind was the effects of strong winds; great care had to be taken in the design of fastenings and similar items to secure the asbestos-cement cladding. In addition, to counteract the unusually severe weather conditions all external steelwork is grit blasted and zinc sprayed before erection and subsequent painting. Buildings were grouped loosely to allow for future expansion. The main civil engineering contractors were Whatlings Limited; the structural steelwork sub-contractor was Alex. Findlay and Company, Limited.

3—Fast Reactor Group

In discussing construction work for the fast reactor group reference will be made to the reactor containing sphere and to the associated buildings which lie to east and west of the reactor. The reactor itself has already been described in detail, last week.

Fast Reactor Sphere

The fabrication and erection of the 1,500 ton 135 ft. diameter fast-reactor containing sphere was carried out by the Motherwell Bridge and Engineering Company, Limited, and more than 350 steel plates were used in its construction. These plates, which are formed from Colvilles' Coltuf steel, are 24 ft. by 12 ft. by $1\frac{7}{8}$ in. in size and weigh about 10 tons. The sphere is supported on a circular welded steel skirt with heavy ring reinforcements and requires considerable anchoring. Site fabrication was performed in a workshop at Dounreay, where plate segments were welded together in pairs to reduce on-site welding.

The sphere, set on a 10 ft. thick reinforced-concrete foundation raft, was built from the skirts upwards, with plates clipped together and tied back with booms to a centre tower before welding. The bottom half was constructed between July and December, 1955, and the top half between July and December, 1956. The construction work inside the sphere was carried out between January and June, 1956. The airlock was delivered to site in rings, assembled and welded in the site workshop, and lifted in one piece. The bellows ring was designed and made by the British Appliances Manufacturing Company, Limited, of Leeds, and the door mechanisms were designed and manufactured by Strachan and Henshaw, Limited, of Bristol. Lloyds Register of Shipping, Lands Division, acted as the Authority's inspection agents from the making of the steel to the completion of the work on site. All welders were tested and all containment welds were X-rayed. Before commissioning, the sphere will be pressure tested.

Over 300,000 ft. of " Fortrex 35 " electrodes made by Murex Welding Processes, Limited, are said to have been used for the manual arc welding of the sphere. In addition, " Nicrex " electrodes were employed for welding the 30 ton stainless-steel reactor vessel, and for other work on the site.

Fast Reactor Buildings

The buildings associated with the fast reactor number seven in all. The reactor administration building contains the control room for the fast reactor, offices, laboratories and workshops. It is a steel-framed building having three floors, asbestos-cement clad, with metal windows and steel deck roofing. The floors, with certain exceptions, are of pre-cast concrete units. The active element store is adjacent to the administration building, with which it shares an electric lift. It provides facilities for handling the reactor elements both before and after use, and incorporates a pond for storage of these elements after discharge from the reactor. A sodium stripping area is available for dealing with contaminated equipment. The building is connected to the sphere by the airlock which gives the only access to the reactor at the sphere's equator. The heat-exchange building is also of steel-frame construction and is 62 ft. high. It contains the heat exchangers and forms the landward termination of the pipes from the sea-water pump house. The steel-framed Diesel generator building contains the generating sets which supply auxiliary power to the fast reactor. Between this building and the heat exchangers, all three forming an integrated composition, is the link building, which is partly of steel-frame and partly reinforced-concrete frame construction. It houses the switch room, battery room, workshop, offices and change rooms. The sea-water pump house, which was designed by Sir William Halcrow and Partners, and is sited on the cliff face, is of reinforced-concrete construction and

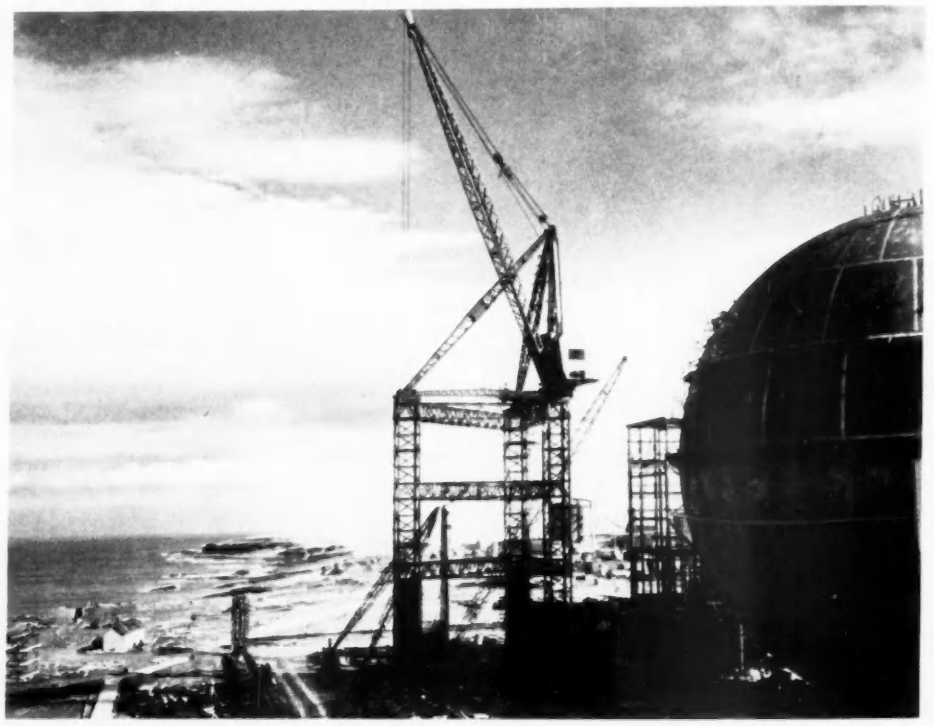

Fig. 14 The special nature of the construction at the Dounreay establishment due to exposure may be gathered from this view of the site, which shows part of the fast reactor sphere and, behind the crane, the containing cylinder for the materials testing reactor.

houses the motors and pumps for the cooling water. The turbine hall, at present in the design stage, is a steel-framed two-storey 46 ft. high building forming a northward continuation of the heat exchanger building. It will contain one turbo-alternator set.

4—Materials Testing Reactor

The designers and main contractors for the Dounreay Materials Testing Reactor (DMTR), which was described in our Atomic Review on May 24, were Head Wrightson Processes, Limited, who were also responsible for supervision of construction. Fabrication and erection of the cylindrical shell, as of the fast reactor sphere, was carried out by the Motherwell Bridge and Engineering Company, Limited.

Containment Vessel

The containment vessel is a circular steel shell 70 ft. in diameter and 70 ft. high, which forms an hermetically sealed building. The shell is built on a concrete raft, 84 ft. in diameter and 7 ft. 6 in. thick. A steel-plate floor on top of the raft welded to the shell completes the seal. A steel floor is provided at the 15 ft. level and a 25 ton overhead electrically operated travelling crane is supported from the shell. Access airlocks are provided. Requirments for the design of the shell, airlocks and access doors were: to conform with B.S. 1500 for fusion welded pressure vessels; and to withstand wind velocities of up to 100 m.p.h., an internal pressure of up to 6·5 lb. per sq. in. gauge in an emergency, and external pressures up to 1·0 lb. per sq. in. gauge due to variation in atmospheric pressure. To resist the upward forces caused by the internal pressure, ten stiffening ribs are provided spaced equally round the shell. The stiffeners are extended beyond the base of the shell and cast into prepared pockets in the raft. External ribs had to be added for stiffening and for carrying the load from the crane. The junction of the roof through the radius knuckle presented some problems but the completed knuckle was preassembled in the shop.

Airlocks

Three airlocks are provided, one for vehicles and one for personnel at ground floor level, one for emergency exit at first floor level. The doors are so interlocked that either door can only be unclamped and opened when the other door is closed and clamped. The doors were designed and fabricated by J. Stone and Company (Charlton) Limited.

Cooling Towers

Instead of the conventional hyperbolic concrete cooling towers, " Fluor Counterflo " cooling-water plant is used for the materials testing reactor. Supplied by Head Wrighton Processes, Limited, this plant employs mechanical draught and is of low and compact construction, as can be seen from Fig. 16. It makes use of a special pre-fabricated construction, and prototypes were described in ENGINEERING, vol. 182, page 76 (1956).

Fuel Element Plugs

The 130 fuel element shield plugs used in the DMTR reactor have been produced by Savage and Parsons, Limited, in conjunction with the United Kingdom Atomic Energy Authority. Each plug—approximately 4 ft. 6 in. long and 4 in. in diameter—is made from a titanium-stabilised stainless-steel tube which is filled to a specified density with concrete and iron shot and a 4 in. layer of lead. Stainless-steel plugs are welded into the ends. Also housed in the main tube are three stainless-steel " purge " tubes, through which air or gases can be cleared from around the fuel element, and a centre plug which can be withdrawn to facilitate the removal of water and chemicals from the core of the reactor. The fuel element and cooling sheath is attached to the bottom of the plug by a clamping ring.

Tubes

In the materials testing reactor (DMTR) at Dounreay, the Talbot Stead Tube Company, Limited, were responsible for the manufacture and fabrication of stainless-steel pipework for the following applications: heavy-water coolant, instrumentation, helium-coolant circuit, supplementary cooling, and the shield cooling circuit.

5—Chemical Group

The chemical group at Dounreay comprises four main sections, concerned with (1) fuel-element fabrication, (2) chemical separation and billet production, (3) effluent disposal, and (4) chemical analysis. The work of certain sections will be referred to here in describing some of the construction work involved, but a more detailed examination of fuel processing will be treated in a subsequent issue in Atomic Review;

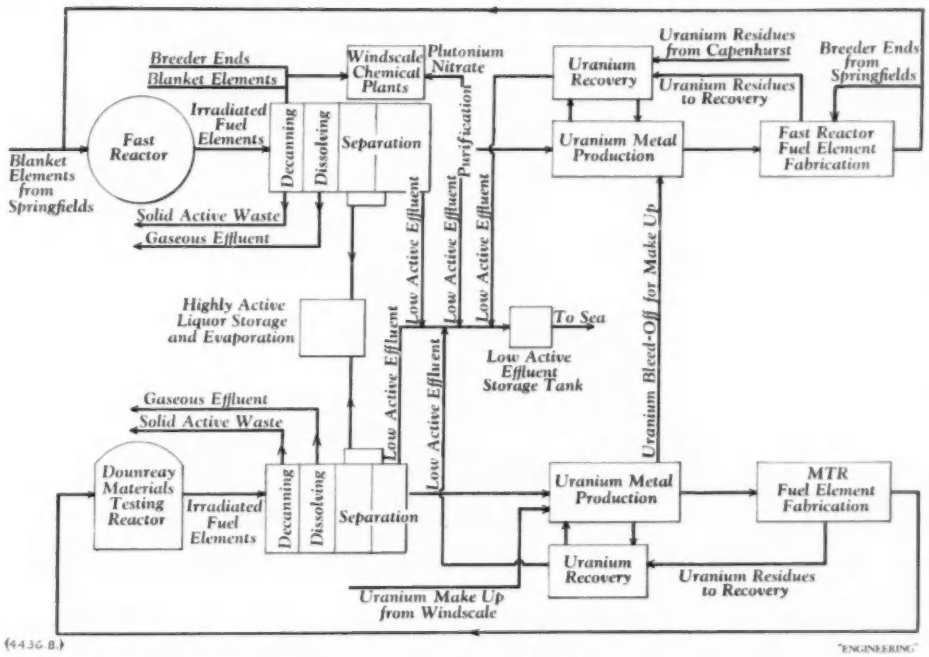

Fig. 15 (above) Enriched and natural uranium fuel processing cycles for the Dounreay reactors. In addition to the wide range of plant required for these operations, the establishment includes a number of laboratories and other experimental facilities.

Fig. 16 (left) The Fluor Counterflo cooling towers which have been built to serve the Dounreay materials testing Reactor.

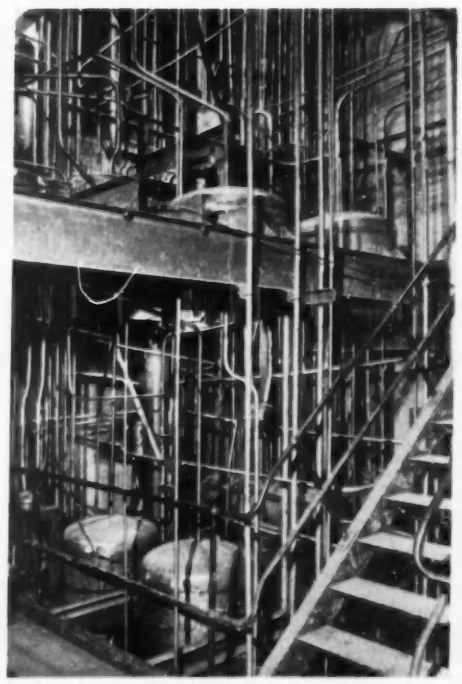

Fig. 17 (right) Stainless-steel pipework installed in a highly active cell by Thos. W. Ward Limited. Radioactive liquors from the chemical separation plants are concentrated for storage since the activity persists for many years.

however, the work of the sections can be briefly summarised (see Fig. 15).

In the fuel-element fabrication section there are two distinct processes. In the first, enriched uranium metal is made into fuel elements for the fast-fission reactor; in the second, fuel elements for the material testing reactors at Dounreay and Harwell are manufactured from highly enriched uranium. In the chemical separation and billet production section, the irradiated fuel elements from the fast reactor are dissolved in nitric acid and by means of a solvent extraction process the uranium is separated from fission products and plutonium. The pure uranium in a solution of nitric acid passes to the billet plant where it is converted to metal by metallurgical processes. The billets of pure uranium metal are then returned to the fuel element fabrication plant. A similar process is used to deal with irradiated fuel elements from the materials testing reactor. The disposal of radioactive effluent from the chemical plants is likewise the concern of a section. Highly active waste products from the chemical separation processes are stored indefinitely in underground storage tanks. Waste of very low activity is diluted and at high tide is pumped out to sea along an underground pipeline. The tidal current disperses it and it becomes highly diluted in the sea. The laboratory is the responsibility of the chemical analysis section and is the control building of the chemical group.

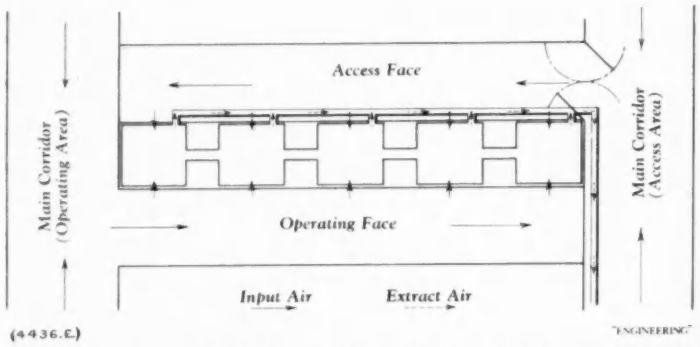

Fig. 18 Ventilation of typical process line. Most chemical processing buildings at Dounreay are divided into working and plant areas. Fresh air is drawn into the working area and extracted from the plant area.

Fig. 19 (right) Chemical process line for the production of materials testing reactor type fuel elements.

Effluent Disposal

The complexity of the chemical plant may be gathered from a description of the effluent disposal processes. Fig. 17 is a view of pipework installed by Thomas W. Ward, Limited, in the highly active cell.

Highly Active Liquid Effluent.—The fission processes which take place in the fast fission and Materials Testing Reactors at Dounreay produce fission products in addition to liberating energy in the form of heat. The degree of radioactivity of the long-lived fission products constitutes a hazard since the activity persists for many years. This renders the immediate discharge to sea of liquors containing these fission products impossible and the liquors are, therefore, stored in stainless-steel tanks. Evaporation has been chosen as the easiest and most convenient method of reducing the bulk of the fission product solutions and thereby conserving expensive storage space.

The highly active effluent is discharged to the building through two separate pipe lines, one taking evaporable liquor and the other non-evaporable liquor. The non-evaporable liquor is the DMTR chemical separation plant waste liquor which contains sufficient aluminium nitrate to make evaporation inadvisable because of crystallisation dangers. This non-evaporable liquor passes direct to storage and the evaporable liquor is directed to holding tanks in the building. From the holding tanks, the highly active liquor is transferred batchwise to a constant-volume feeder in the evaporation cell. This transfer is effected using a vacuum lift technique, the vacuum being produced by a steam ejector. The liquor is then fed through a steam strip column, which removes the volatile tributyl phosphate and kerosine, and then to a continuous evaporator. The concentrated fission product solution is transferred to storage and the condensate from the evaporation is monitored and discharged to sea. The plant is constructed so that all the active section of the plant is situated behind concrete biological shielding with all control equipment situated outside the shielding.

The concentrated active liquor in storage contains several important isotopes, for example, caesium 137 and strontium 90, which have industrial and medical uses. Provision is made in the plant for the withdrawal of liquor from the storage tanks and its transfer to a future extraction plant for isolating and purifying these isotopes.

Low Active Liquid Effluent.—The low radioactive liquid wastes from all the chemical plants, reactors and active laboratories are discharged directly to two holding pits and thence to sea. Each building neutralises its effluent before sending it, by way of a cast-iron pipe, to the lined pits. The pumping is done by three pumps, which are situated adjacent to the pits. Pumping is commenced one hour after high tide to ensure that the effluent is drawn away from the shore.

Gaseous Effluent.—Most buildings are divided into working and plant areas, as shown in Fig. 18. Fresh air is sucked or blown into the working area then extracted from the plant area. This arrangement ensures that personnel are always working in a fresh-air atmosphere, and should a leak develop on the plant side, the direction of flow would ensure that any contamination would be carried away in the extract system. In certain operations where active dust or gas is produced, all work is carried out in totally enclosed glove boxes. A special extract system removes the contaminated air which is then passed through special filters before going into the main extract system. The extract from each building is connected to a main duct which runs the full length of the chemical plant and terminates at the fan house and chimney. For normal operation two fans each driven by separate electric motors provide the extraction. In the event of an electrical supply failure a Diesel engine automatically cuts in and drives one fan only, thus ensuring continuity of extraction in all cases. In chemical plants which process irradiated fuel elements, gases (iodine 131, xenon or krypton) and fine particulate matter (uranium oxide or fluoride) which may be radioactive are released during decanning, dissolution in chemical reagents, and chemical treatment of solid material. The gaseous effluent system and control is designed to deal with all these types of effluent in such a manner, that the quantity and rate of discharge can cause no ill effects in the surrounding area.

Pipework and Fabrication

Thos. W. Ward, Limited, have been responsible for the installation of laboratory plant, including stainless steel, mild steel, copper and alloy pipework together with pumps, valves and fittings. Many thousand feet of stainless-steel pipework of different qualities and gauges have been installed in various parts of the site, all fabricated and welded on site and subsequently subjected to stringent examination and radiographic inspection. In addition, tanks of various sizes have been installed and numerous vessels made from stainless steel and mild steel to U.K.A.E.A. specifications. A great deal of the outside work was executed in processing and experimental cells, one of which is shown in Fig. 19. The flooring of the cells was completely clad with stainless-steel plate and the welding carried out to a rigorous specification. Other work carried out by Wards at Dounreay includes graphite laying, installation of control gear, pumps, process plant vessels and other items.

Ventilation

The ventilation of laboratories and ancillary buildings has been primarily the concern of Henry Hargreaves and Sons, Limited. The filtered warm air supply and active air extraction systems serving the main chemical plant buildings consist of ductwork systems constructed from galvanised and stainless steel. The main supply and extract ducts convey fresh air to "clean" areas and exhaust foul air from "dirty" areas. The air movement in the buildings is induced from a main extract plant remote from the laboratories and connected to each building by underground concrete ducts. The construction of the buildings is such that negative pressure created by extract fans induces the fresh air supply through the duct system and filtration plant. In each of the laboratories a system of stainless-steel extract ductwork serves the cubicles and glove boxes. This part of the work is of welded construction, the joints being welded *in situ* and subjected to a test pressure of 5 lb. per sq. in. gauge.

Laboratories

There is not space here to deal fully with the work of the laboratories but reference to a few particular items can be made. The laboratory building, which is 440 ft. long by 92 ft. wide is, apart from the reactors, perhaps the most complex single building on the site. It contains, on one floor, highly, medium and low-active laboratories with additional space for workshops, stores, plant room, mass spectrographic laboratories, dark rooms, and other premises. A particular feature is the care which was taken to provide a comprehensive system of services which are so dispersed as to allow a maximum degree of flexible planning both in the present stage and to cope with future requirements.

Irradiated Fuel Elements.—Pye Limited are designing and supplying all the equipment for a

laboratory in which irradiated fuel elements from the fast breeder reactor are to be examined. The equipment to be supplied includes manipulators, universal cutting machines, a lathe, furnaces, machines for X-ray and density measurement and for inspection and materials-testing, optical and television viewing facilities, and all the associated handling and shielding equipment. Owing to the highly radioactive nature of the elements, which can only be handled remotely, the laboratory is a cave of U-shaped form—a concrete cave 1,100 sq. ft. in area. For shielding purposes the walls of the cave are 4 ft. 6 in. thick, partly lined with steel. For observation of the processes inside the cave there are windows at intervals in the dense concrete walls. These windows are composed of glass-walled tanks containing a saturated zinc-bromide solution, thus providing a shield from radioactivity equal to that of the walls, and at the same time permitting observation of all the processes. At each window, facilities are provided for Pye Master Slave Manipulators for remote handling of the elements. Pye manufacture these manipulators by agreement with AMF Atomics, a division of the American Machine and Foundry Company. When close examination of the processes inside the cave is necessary, optical periscopes and closed circuit television are used.

The cave is divided into ten separate test stations for carrying out the various mechanical, physical and metallurgical operations required, all of which must of course be remotely controlled, in many cases under water. The examination and measurement of the internal and external diameters of the element calls for the use of a permanently fixed Pye industrial television camera. The de-canning of elements and removal of their rare-metal sheaths involves the use of special cutting machinery, including a remotely handled lathe for the preparation of test samples. The metallurgical tests possible include X-ray examination, density measurement, tensile and impact testing, and remote viewing of specimens under the microscope. Provision has been made for carrying out heat treatment where necessary. The highly active state of the element makes it imperative that all waste and swarf must be carefully collected and disposed of; for this purpose remote canning machines are installed and a check against loss is kept by weighing.

Mass Spectrometry Equipment.—The Metropolitan-Vickers Electrical Company, Limited, has supplied an MS2 mass spectrometer for the isotopic analysis of heavy metal halides such as uranium hexafluoride. This machine is basically similar to the standard type of general-purpose mass spectrometer, which is widely in use in industry and academic research. The corrosive nature of uranium hexafluoride vapour, however, necessitates a special gas-handling system and ion source. Later this year, an MS3 mass spectrometer will be dispatched to Dounreay. This instrument is a standard machine designed for routine analytical work on gases. Early in 1958 a different type of mass spectrometer, designated type MS5, will be delivered. This instrument can be used for the rapid determination of isotope ratios of solid samples which can be handled using the surface ionisation technique.

Vacuum Furnace Equipment.—High-frequency vacuum induction furnaces together with their associated equipment for the purpose of casting uranium and uranium alloys have also been provided by Metropolitan-Vickers. The present installation, which is now in operation, covers nine such furnaces supplied from three 25 kW motor-generator sets together with control cubicles, capacitors, and selector switches; it is divided into two separate schemes which are electrically and mechanically separate but are so designed that a large percentage of the equipment is interchangeable reducing stocks of spares to a minimum. Each furnace is designed for melting in graphite crucibles and under high vacuum. Owing to the nature of the product all the operations are carried out in the glove boxes. The actual inductor coils are water-cooled and are protected by water-flow relays and should the water supply fall below the minimum requirements the visual and audible warning systems are brought into operation, at the same time automatically switching off the high-frequency electrical supply and thus preventing damage to the coils. Power cannot be switched on again until an adequate cooling water supply is available. This protective system is also brought into operation on vacuum failure by the inclusion of a pressure switch in the vacuum line which actuates a relay causing a magnetic valve to close in the water supply line; this ensures that a charge cannot be heated in atmospheric conditions.

6—Power and Auxiliaries

The electrical power supply to Dounreay is obtained from the North of Scotland Hydro-electric Board at 33 kV at the main substation on the site. This forms the only source of electrical power for the chemical group, and the administrative and workshops group. The fast reactor, while using the supply as far as possible, depends on local Diesel-electric generators for all supplies because an interruption even for a short while cannot be allowed, and the materials testing reactor is equipped with Diesel generators forming a standby source of power. At the main substation, the 33 kV supply is transformed to 11 kV, and distributed over an 11 kV network of underground cables to four 11 kV substations. Two of these substations supply the chemical group, one the fast reactor and one the materials testing reactor. The main substation also supplies the administrative group workshops. At the main substation and the

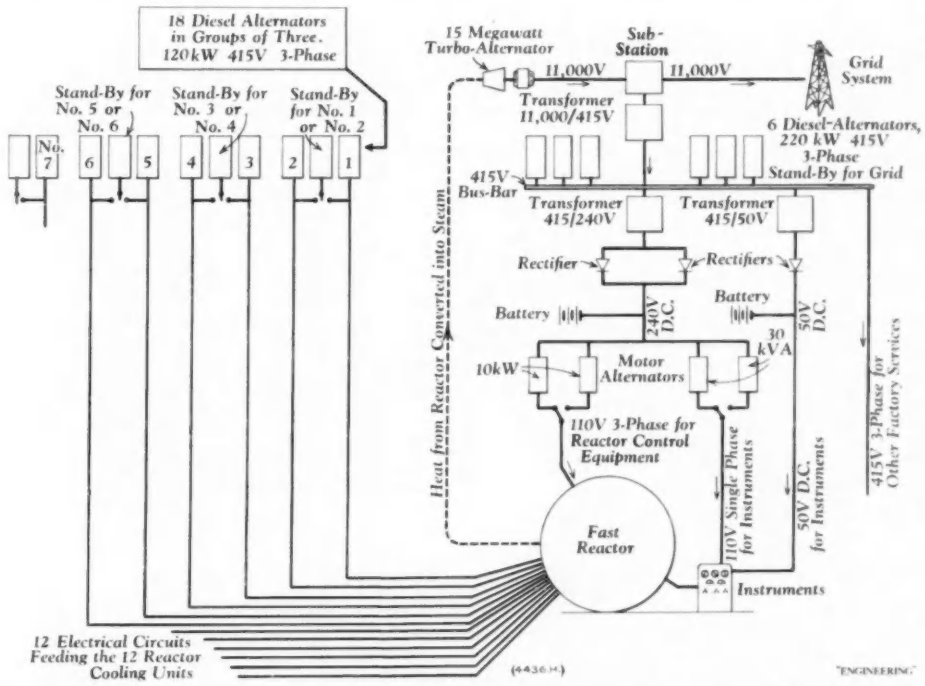

Fig. 20 Electrical supply distribution for fast reactor. Auxiliary supplies are an essential feature of the system, since failure of the electromagnetic pumps might lead to melting of the reactor core.

Fig. 21 (left) One of several switchboards built by Brookhirst Switchgear Limited for controlling the fast reactor.

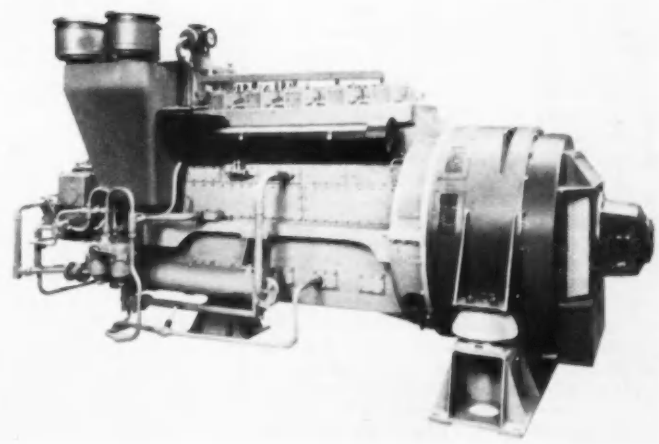

Fig. 22 (right) Three Crossley ESL5 scavenge-pump Diesel engines developing 200 b.h.p. at 600 r.p.m. and driving Bruce Peebles alternators serve as standby sets supplying the fast reactor. They are designed to start automatically on failure of the mains supply.

11 kV substations, the supply is transformed to 415/240 volts and then distributed to the various buildings.

The main electrical contractors at Dounreay are James Scott and Company, Limited, whose work covers supplies to the chemical group, temporary installations during construction of the reactors and other items, and control and distribution.

Switchgear and Transformers

The switchgear in the main substation has been supplied by A. Reyrolle and Company, Limited, and consists of 11 kV 350 MVA oil circuit breakers of the horizontal isolation type. The busbar arrangement is duplicate busbars with a section switch in the main bar and bus couplers between each section of the main bar and the reserve busbar. Oil-immersed busbar selectors on the oil circuit breakers give facilities for on load selection of busbars. A castell key interlock ensures that the appropriate bus coupler is closed before the selector on the oil circuit breaker can be moved. The switchgear in the two 11 kV substations on the ring main is similar to that in the main substation apart from the busbar arrangement which comprises a single busbar with section switch. Fire protection in the switchrooms is given by a carbon dioxide installation operated automatically from fusible links in the switchroom and with facilities for hand operation. The interconnector switches on the 11 kV ring main can be operated by remote control from the main substation.

The main 415 volt boards consist of 35 MVA air-break circuit breakers, also made by Reyrolle and Company, of the horizontal draw out type with current ratings up to 1,600 amperes. The busbar arrangement is single busbar with section switch and with each section of the busbar being fed by a 1,000 kVA transformer. From these boards cables run to the distribution boards in the factory buildings. These feeders are controlled by air-break switches fitted with overcurrent and earth fault relays at the supply end and by air break isolators at the remote end. The distribution boards in the factory buildings are made up of air-break switch fuse gear.

Fast Reactor Supply

The fast reactor is a power-producing plant capable of feeding 15 MW of electricity into the Grid. It must be borne in mind, however, that it is primarily a pilot plant and an instrument of research, and it is not to be expected that the reactor will produce this amount of electricity continuously, especially during the early stages. The reactor needs to be supplied with some electricity, for pumps, heaters, instruments, lighting and other items. Some of this will be taken from the Grid, and some will be generated in a power house on the fast reactor site.

The reactor is cooled by 12 independent cooling units, and the electrical equipment which serves each of these units is on a separate circuit. Twelve Diesel alternators (one to each circuit) supply the power to this equipment. In addition, there are six further alternators standing by.

The remaining electrical requirements of the reactor may be divided into three main groups, depending upon the consequences of a failure. These may be listed as follows: plant, in which a failure of the electrical supply would cause the reactor to shut down; instruments, in which a failure would mean that the operators would have no knowledge of what was happening within the reactor; and other factory services, in which a failure would have no immediate effect on the running of the reactor.

The diagram in Fig. 20 shows how power is supplied to these three groups. After transforming the Grid voltage to 415 volts it is fed into a busbar. Six Diesel alternators (each 220 kW) are standing by to feed into this busbar in the event of Grid failure. From this busbar, the current is transformed (and rectified where necessary) to suit the electrical plant. Where a break in the continuity of supply is inadmissible, that is, in the first two categories above, direct current is used and batteries are connected to the circuit to provide a reserve supply while change-over from Grid to Diesel-alternators is being effected.

Fast Reactor Generating Plant

The General Electric Company, Limited, is to supply the electrical generating plant for the fast breeder reactor. The equipment will consist of one 15 MW steam turbo-alternator set and the power generated will be fed into the North of Scotland Hydro-Electric Board Grid. The design of the turbine is generally similar to that of the standard G.E.C. single-casing machine, but it incorporates a number of special features on account of the unusual steam conditions imposed. Inlet steam will be at the comparatively low pressure of 150 lb. per sq. in. gauge and temperature of 518 deg. F. The turbine thus has to handle a very large volume of steam at inlet, and steam inlet pipes, governing and emergency valves of large capacity will be provided.

It is envisaged that the steam conditions may be improved later to 200 lb. per sq. in. gauge and 622 deg. F. The turbine has been designed to operate under these higher inlet conditions without modification. This would inevitably be accompanied by some reduction in internal efficiency, and provision has therefore been made for fitting a new nozzle block and two additional stages should a higher efficiency be desired.

The alternator is a standard 3 phase, 50 cycles air-cooled machine with a power factor of 0·85. The alternator will generate at 11,000 volts and has a short-circuit ratio of 0·8 to tie in with the North of Scotland Hydro-Electric Board system. The exciter will be direct-coupled to the alternator, and is being supplied with a magnetic amplifier for automatic voltage regulation.

Fast Reactor Control Gear

Brookhirst Switchgear, Limited, have made, or have orders in hand for, the control equipment for the auxiliary plant of the Dounreay fast reactor. The control equipment includes four switchboards, one of which is shown in Fig. 21. It incorporates eight 25/3 horse-power two-speed direct-on automatic contacter type starters for the cooling tower fans. The other three switchboards are designated "alternator control board," "distribution board" and "reactor control-rod contactor board." These boards are directly concerned with the electrical supply to and control of the operation of the control rods, shut-off rods and safety rods. The alternator control board controls two direct-current motor-driven 10 kW alternators with 110 volt, 50 cycle, 3 phase outputs which are caregully regulated automatically for voltage and frequency, and there is provision for load sharing at a later date if required. These supplies are then paralleled by isolators in the distribution board, which incorporates a reversing contactor for each of the 12 rods. The reactor control-rod contactor board includes various arrangements of change-over contactors which control the coil circuits of the reversing contactors in the distribution board and possibly some other auxiliary circuits.

Diesel Auxiliaries

Crossley Brothers, Limited, are installing 34 two-cycle scavenge pump Diesel engines for service at Dounreay. Twenty ESL5 type vertical two-cycle 5-cylinder scavenge-pump Diesel engines, rated at 200 b.h.p. at 600 r.p.m. will be installed in the generating house. Each set drives a 120 kW, 3 phase, 50 cycle Bruce Peebles alternator. Six ESV 8 type, V-form, two-cycle, 8 cylinder scavenge-pump Diesel engines, rated at 360 b.h.p. at 600 r.p.m. will also be provided, each set driving a 220 kW, 3 phase, 50 cycle Bruce Peebles alternator.

Three ESL5 vertical two-cycle 5 cylinder scavenge-pump Diesel engines, rated at 200 b.h.p. at 600 r.p.m. will serve as standby sets for the fast reactor, each set driving a Bruce Peebles alternator similar to those in the generator house. These sets are designed to start automatically on failure of the mains supply by a solenoid-operated automatic starting gear which introduces air into the engine cylinders. They are shown in Fig. 22.

Four ESN8 vertical two-cycle 8 cylinder scavenge-pump Diesel engines have been provided for the sea-water pump house. They are rated at 320 b.h.p. at 600 r.p.m., driving through "Twiflex" automatic clutch and flexible couplings to a David Brown gearbox, and hence into a Gwynnes centrifugal pump. One ESN3 3 cylinder vertical two-cycle scavenge-pump Diesel engine, rated at 192 b.h.p. at 960 r.p.m. will be employed as standby set for the fan ventilation system. This set is fully automatic on mains failure, and Airflex clutches incorporated in the shaft system enable drive to be obtained automatically from either end of the engine to either of the two double-shaft motors.

For lubrication of the Diesel engines, Shell Rimula Oil 30 will be used.

7—Cranes

In addition to the cranes used in construction, a number of permanent cranes are installed at Dounreay.

Crane for Fast Reactor

J. H. Carruthers and Company, Limited, built the 25 ton rotating crane which is housed in the fast reactor sphere. It is supported on the concrete vault and carries two hoists.

The 30 ton electric overhead travelling crane being supplied by Paterson Hughes Engineering Company, Limited, is a 4 motor crane operating on direct current supplied by a Lancashire Dynamo Nevelin rectifier mounted on the floor. The leading particulars of the crane are as follows.

Main hoist capacity	30 tons at 5 ft. per min.
Auxiliary hoist capacity	5 tons at 20 ft. per min.
Cross travel speed	45 ft. per min.
Longitudinal speed	50 ft. per min.
Span of crane bridge	57 ft. 8½ in.

Both hoist motions are provided with potentiometer diverter control embodying dynamic braking and both travel motions also incorporate diverter control. By this means precise positioning of the hook can be obtained. Each hoist controller is fitted with a dead-man's handle and limit switches are fitted to all motions. Two entirely separate hoist motions are mounted on the crab of 30 tons and 5 tons capacity respectively. This crane provides the main lifting facility in the building housing the reactor.

Cranes for MTR and other Plant

Among the cranes made by the Wharton Crane and Hoist Company, Limited, for the Dounreay establishment is a 25 ton 3 motor enclosed type circular-motion crane in the materials testing reactor building, details of which are as follows.

Track diameter	66 ft. 6 in.
Clear lift of hook	60 ft.
Operating speeds	
Hoist—fast	16 ft. per min.
slow	2 ft. per min.
Cross traverse	60 ft. per min.
Revolving speed	15 ft. per min (at runners)

Other Wharton cranes at Dounreay are a 20 ton 4 motor crane in the turbine house, a 10 ton single-motor crane in the Diesel engine hall, a 10 ton single-motor crane in the sea-water system load pumping bay, a 5 ton hand crane in the screen house, and two 12 ton 3 motor cranes, a 25 ton 3-motor crane, and a 25 ton 3-motor crane in various other buildings, making 9 in all.

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In the introduction to our article, "Prospect for Dounreay" (May 17, page 610), the conversion product of thorium was inadvertently said to be thorium. Non-fissile thorium is of course converted under neutron irradiation into fissile uranium 233.

Marketing

TEACHING MARKETING SKILLS

An attempt is being made by the Dollar Export Council to encourage British exporters to make greater use of technical market research when competing in highly competitive markets, particularly those in the dollar areas. Acting in conjunction with the European Productivity Agency of the Organisation of European Economic Co-operation, the Council arranged a series of conferences at which two of America's top marketing experts, Professor Robert G. Seymour and Mr. Charles M. Johnson are passing on to leaders of British industry some of their knowledge and experience of marketing.

At a Press conference held at the Dollar Export Council's headquarters, Dr. Seymour and Mr. Johnson discussed the purposes of these conferences and the impressions they have formed during their tour of Britain. They visited Glasgow, Leeds, Manchester, Nottingham, Cardiff and Birmingham and have therefore talked about marketing and market research to a wide cross-section of British industry. The talks were summarised by Sir Edward Herbert, chairman of William Hollins and Company, Limited, as an attempt " to overcome a certain prejudice against market research which seems to exist in this country, and to show that there is nothing fanciful or mysterious about the scientifically developed and fully proved methods of finding out the facts of a market."

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Opportunities in Plenty

The keynote of the conferences held by Dr. Seymour and Mr. Johnson—who are respectively professor of commerce and business administration, University of Illinois, and president of Washington Steel Products, Inc.—was the conviction they expressed that exports of British goods to the dollar markets could be considerably increased " because there are gaps in domestic production which British manufacturers could certainly fill." On the other hand, it is most unlikely that any expansion will in fact take place unless manufacturers are willing to study the market thoroughly and methodically.

In answer to questions concerning the types of goods which would sell in the United States, Dr. Seymour mentioned " most sectors of engineering, scientific instruments, toys, speciality goods and men's shoes." He emphasised the fact that most competition to-day is " non-price competition," based on brand appeal and on the manufacturer's ability to give the market what it needs at the time. An example given was the change in consumer preference from light to medium bicycles, which favours German makes. This change could doubtless have been foreseen by regular market research.

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Automation for the Consumer

The influence of modern technology on the service provided in United States retail establishments for the benefit of the consumer is the subject of a booklet written by Sir Walter Puckey after his last visit to the United States.

The booklet is a stimulating account of what is done to make the American consumer more comfortable when he shops, and to simplify his selection of goods. For example, " pre-preparation of commodities such as meat and vegetables is carried a long way and to watch a husband picking up and choosing from a wide selection of Celophane-wrapped, boned and trimmed joints, each clearly marked with weight, description, code number and price, was an interesting experience." But Sir Walter's main concern was in finding out how modern techniques are applied to produce these results. The use of data-processing machines, of punched card equipment, of labelling, weighing and packaging machinery, is illustrated in various applications. The booklet should prove a most useful guide for those who seek new outlets for their inventiveness or for their products.

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" Skilled, Choosy, Culture-Hungry "

The manufacturers and sellers of consumer goods in the United States are discovering a new type of customer. Market research and the hard experience of trying to sell have produced a picture of the American consumer radically different from the traditional type. The former willingness of the American buyer to take standard products without any desire to be different from their neighbours—is being threatened by a change towards more definite (less influenceable) and more varied tastes. The United States businessman now has to identify these tastes and to provide the variety of products the consumer wants.

This change is of the greatest importance to British exporters. It has not happened overnight; for several years now travel and education have tended to change the American's attitude to what he buys. The average American, if he can still be so described, is subject to new influences—many of them advertisements through magazines (the cartoon is a powerful means of changing outlooks), radio and television—which lead him towards variety and towards the desire for being different from the mass. In an amusing (perhaps unwittingly) and challenging article in their issue of May 4, *Business Week* describe the new American customer as " skilled, choosy, culture-hungry." There lies an opportunity which no maker of consumer goods should neglect.

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Buying Know-How and Time

Even the largest companies are realising that once a competitor has produced something new the time required to catch up is likely to be more than is commercially feasible. Buying know-how is buying time and also, in a sense, buying additional research and development capacity, although few companies are likely to be successful and get the most out of a manufacturing licence unless they have substantial research and development capacity. But granted something approaching technical parity between licensor and licensee, the practice can be of immense benefit to the countries concerned.

Armstrong Siddeley Motors have concluded a licence agreement covering the manufacturing and selling rights in Britain of the auxiliary power gas-turbines and air-turbine starters developed by the AirResearch manufacturing divisions of the Garrett Corporation, Los Angeles. The Hawker Siddeley Group, who will have exclusive distribution rights in all British territories other than Canada, described the association as of " great importance in view of the fact that auxiliary power units providing an independent source of staff power and/or pneumatic power for engine starting and aircraft services have already become a necessity for large civil and military aircraft."

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Higher Output Forecast

A marked rise in industrial production during the second half of this year is forecast by the country's leading economists. For the sixth year in succession the Study Section of the Royal Statistical Society invited about 100 economists and statisticians outside Government service to forecast the movement of five big economic indices during the current year. Sixty-seven answers were received, revealing a strong expectation of a new business boom, marred perhaps by some degree of inflation.

The general expectation is for a sharp rise in industrial output in the closing months of the year, and a decline in unemployment. The proportion of unemployed is expected to average 1·3 per cent. for the full year, and since it has been running at between 1·7 and 1·8 per cent. during the first quarter it is clear that by the third quarter the shortage of labour will be as acute as it has ever been. The most disturbing aspect of the forecast is the economists' expectations of a smaller increase in exports this year than last, but a much larger rise in personal consumption in the home market. Although some of this—cars and electrical household appliances are major items on the list—will be provided by higher production, some of it will have come from higher imports. This could bring about a situation similar to that which led to the imposition of the Government's credit controls, and result in a further tightening up.

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Selling Civil Aircraft

The battle is now on between America, France and Britain for the lucrative markets that are opening in civil aviation. Western Germany is a late starter but doubtless aims to be among the leading suppliers of aircraft to the world's airlines within four or five years. At the Paris International Show which began last week all the major manufacturers are putting the weight of their efforts on civil products.

The scale on which the leading United States firms such as Boeing, Douglas, General Electric and United Aircraft are exhibiting has surprised some of the British participants. Boeing and Douglas in particular have taken very large stands. The British effort is smaller than might have geen expected though still substantial. With the Farnborough Air Display in three months' time, the aim is to awaken the interest of potential customers enough to bring them to Farnborough.

The Paris Fair leaves little room for illusions concerning the selling of civil aircraft: success will depend on the effectiveness of sales promotion almost as much as on the pre-eminence of the product.

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Show Boat for Research

Mobile exhibitions are catching on in the engineering industry at an uncommonly fast rate, and so far the various types tried out—caravans, trains or ships—have proved most successful. Marconi have combined demonstration and research in their yacht Elettra II. The latest equipment made by the Marconi International Marine Communication Company, Limited, which includes a wide range of radar and radio equipment, will be demonstrated to shipping interests in Continental ports in co-operation with associated marine radio companies.

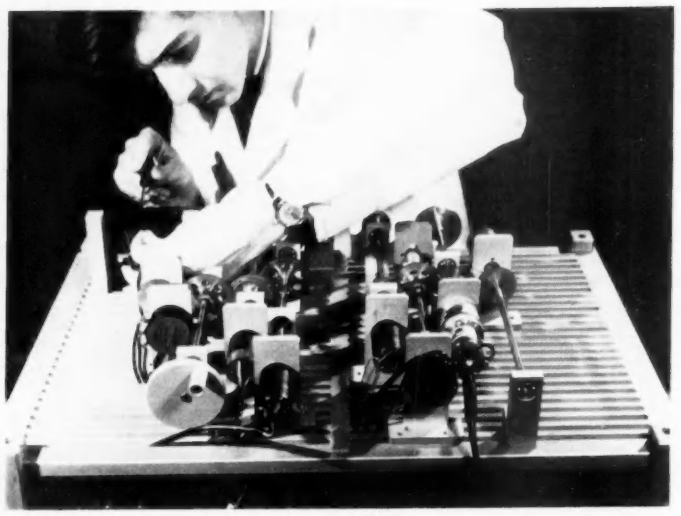
The ship is filled to the brim with the most wonderful telecommunication apparatus, including the " Quo Vadis XII " radar, " Globespan " transmitter and " Atlanta " receiver, all three similar to those installed on the Empress of England. She has also two types of radio-telephone equipment, a " Lodestone " direction finder, a " Gannet " direction-indicating receiver and two types of echometers. The company's range of fish detecting and viewing devices, automatic steering equipment and various radio-telephony transmitting and received equipment are also installed. Elettra II would probably astonish the builder of Elettra I, but no less the buyers of telecommunication equipment in Western Europe.

BASEPLATES FOR EXPERIMENTAL WORKSHOPS

When a new design of apparatus is under way, after the initial " hook-up " comes the " bread-board " stage, when the components are mounted on some convenient piece of material to hold them together and give some idea of the final layout. At this stage, arrangements can be changed to find the most satisfactory layout, and components re-designed to suit the final requirements. Even in the best conducted experimental laboratories, there has to be a bread-board stage in production, and to make matters easier, Vatric Control Equipment Limited, 196 Sloane-street, London, S.W.1, have developed a scheme for baseplate components. One complete lay-out is shown in the illustration. This layout was assembled for evaluation in a matter of hours,

The basic unit consists of a precision machined rigid Duralumin baseplate supported on four legs which can be placed in any convenient position during assembly. The baseplate has a large number of slots making for easy positioning. The component supports, made from high-grade Duralumin extrusion, precision jig-bored and machined to close tolerances, have been designed to accommodate many of the standard International Frame Size servo components, although where non-standard units are used the system lends itself to easy adaption, using locating blocks.

The shaft supports are jig-bored and fitted with precision ball bearings which carry the basic ¼ in. diameter shaft system. Also available are terminal block supports; locating blocks; shaft-angle indicators marked in degrees; shaft couplings which have no backlash, allow considerable misalignment and can transmit up to 20 lb.-in. torque; shaft adapters, which are used to increase artificially the diameter of component output shafts so that they may be conveniently coupled to other components;



Trial rigs are quickly fitted and modified on this machined baseplate.

cranking handles for manually operating input shafts; and pulleys for applying load torques to output shafts. A range of gears of 80 D.P., 20 deg. pressure angle, is also available to suit the ¼ in. diameter shafting and these provide a range between 45 and 350 teeth with a face width of ⅛ in.

GAS-TURBINES WERE CHOSEN

At the Northern Outfall Works of the London County Council, gas-turbines are to be installed to provide the power for the station. The main reasons for this choice were that the supply of sewage gas that would become available when the whole works are complete was estimated to be 2½ million cub. ft. a day which would be sufficient to provide nearly all the power and heat required to operate the station, if it was used in gas-turbines. This would solve the fuel question and, in addition, the maintenance in gas-turbines appears to be less than that required with dual-fuel reciprocating engines. Costs would be saved on maintenance, both by the very small amount of down-time required to service one of the gas-turbines and also by elimination of the need of heavy lifting and handling apparatus. Also due to the short down-time, it was not considered necessary to instal a stand-by generator set for supplying electrical power, thus saving on initial capital cost. The alternators are arranged to run in parallel with the grid so that any additional power required is immediately available from the electricity mains. Thus normally the station will be almost self-contained as regards power requirements, but will be safe-guarded against breakdown by being connected to the grid for whatever electrical power is needed above that which can be generated on site.

In the course of sewage treatment, the settled sludge from the primary sedimentation tanks flows to the sludge digestion plant where it is heated to about 85 deg. F., the heat required for this treatment being provided in the form of hot water—supplied from the waste heat of the turbines. Sludge digestion considerably reduces the bulk of the sludge to be disposed of and at the same time produces sewage gas which is approximately 70 per cent. methane and 30 per cent. carbon dioxide. The effluent from the primary sedimentation tanks flows to the diffused air plant where it is aerated, the oxygen stimulating those bacteria which break down the noxious elements. For this purpose, large quantities of low-pressure air are required, which is injected into the flow through dome diffusers. It is vital that this air supply should not be interrupted, as otherwise the very fine pores in the diffusers would become blocked, and the plant would have to be shut down while the diffusers were removed and chemically cleaned. To guard against such an eventuality special arrangements have to be made to ensure that air is always available. Some of the turbines are therefore used to supply air requirements for effluent purification and the remainder are to provide electrical power. Thus the material that is handled itself provides the power for handling it as well as the air and heat for the bacteriological processes—an excellent example of integrated internal economy.

To supply the air, five Ruston and Hornsby standard gas-turbines are to be installed, each driving a Reavell centrifugal blower of 25,000 cub. ft. per minute capacity at a delivery pressure of 7½ lb. per sq. in. when rotating at 6,000 r.p.m. As the estimated requirement of air is between 75,000 and 100,000 cub. ft. per minute, one set will always be available as a stand-by. Three other gas-turbine sets are to be installed, driving generators to provide the electricity used at the station; they will supply power for all the pumps, scrapers, screens and detritus pit machinery, including the compressors for feeding the raw gas to the turbine combustion chambers.

All eight gas-turbine sets are equipped for alternative firing by heavy oil fuel and, in addition, two of the blower sets are fitted for firing by gas oil. On these two sets the gas oil fuel pump and a lubricating oil pump can be run from the starter batteries, so that in the event of a complete electrical failure, when gas would not be available (gas compressors are electrically driven), at least one blower would continue in use. Automatic equipment provides immediate changeover. In this way it is believed that whatever failures may occur, there will always be a supply of air for the diffusers, although perhaps on a reduced scale.

The installation of the gas-turbines and other mechanical equipment is being carried out under the direction of the chief engineer of the London County Council, J. Rawlinson, Esq., C.B.E., M.Eng., M.I.C.E., M.I.Mech.E., assisted by his divisional engineer (mechanical), Commander S. V. Jackman, M.I.Mech.E., M.I.Mar.E.

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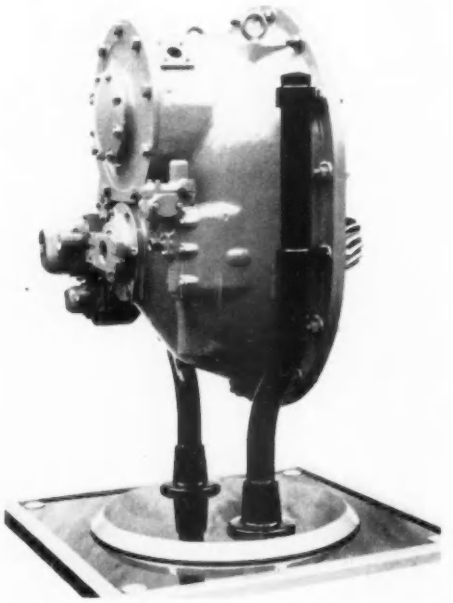
" HOT-SHIFT " GEARBOX

At a recent exhibition given by Rolls-Royce Limited, at Derby, there was shown a " hot-shift " forward and reverse gearbox intended for use in heavy-duty tractors. It is designed to give an easy change from forward to reverse with consequent reduction of driver fatigue. The box is intended to take power from a Rolls-Royce 8-cylinder oil engine followed by an 11,500 series torque converter.

The gearbox consists of an epicyclic train, the sun of which is the input member and the planet carrier the output member. Four pairs of planets transmit the drive from the sun gear to the annulus, the first of each pair meshing with the sun gear and the second with the annulus. Two hydraulically-operated multiplate clutches cause the annulus to be held stationary for reverse drive or to rotate with the planet carrier for direct drive. Changing from forward to reverse gear therefore merely entails engaging one clutch and disengaging the other. A three-phase control valve effects the change, the third position being neutral, and it is not necessary to bring the vehicle completely to rest when changing gear. The box is designed to be bolted directly to the main axle casing of the tractor, and a spur gear train driven from the sun gear shaft provides a full power take-off for a winch. Two auxiliary oil pumps are fitted, one to provide the hydraulic operation of the clutches and the other for lubrication. The model exhibited had a 1 to 1 forward ratio and a 1·11 to 1 reverse.



Using this epicyclic gearbox, a vehicle need not be brought to rest before being put into reverse.

ATOMIC REVIEW

Infinite Variety

THE speculative fascination created by reactor technology lies in its infinite variety. Fuel, moderator and coolant each present so many alternatives in choice of material or arrangement that the number of possible combinations is immense. Then too there are many engineering and metallurgical problems, often of a novel kind, to which these combinations give rise. Some indication of the scope of the subject is provided by the following notes.

Soviet Beryllium-Moderated MTR

The low thermal neutron absorption cross-section and high neutron-scatter cross-section of beryllium make it a very suitable material for reactor moderators and reflectors, but since it is expensive and difficult to fabricate, it was inevitable that the better known and more readily available graphite should receive most attention during the early development of reactor technology. Russian work on the nuclear properties of beryllium was reported during the Geneva Conference, but only recently have details been published of a testing reactor known as BRF, which employs beryllium as moderator, although this reactor, a zero-energy facility in the building of the Atomic Power Station of the Academy of Sciences, became critical in August, 1954.

The BRF reactor comprises beryllium blocks forming a cylinder 104 cm. in diameter by 96 cm. high pierced by vertical channels arranged in a rectangular lattice of cell size 10·7 by 6·4 cm., as indicated in Fig. 1. A 17 mm. diameter channel surrounded by 6 other channels of 14·5 mm. diameter disposed on a circle of 20 mm. radius as indicated in Fig. 3 is placed in the centre of each elementary lattice cell. In addition, there are 108 horizontal channels of 31 mm. diameter.

Powdered uranium oxide (U_3O_8) containing 10 per cent. uranium 235 is loaded into tubular fuel elements (214 gm. U_3O_8 per element), occupying the space between two thin-walled co-axial steel tubes of diameter 13·4 by 0·2 mm. and 9·0 by 0·4 mm., to a height of 96 cm. Two cadmium control and eight cadmium shut-off rods, 8·2 mm. diameter and 96 cm. long are also inserted in vertical holes. Shielding is provided by 1 m. of concrete.

The reactor has been used to determine the critical mass of a number of types of multiplying systems: a uranium-beryllium reactor with and without a radial berryllium reflector; a variant of the uranium-beryllium reactor with six fuel elements per lattice and with graphite bushes placed in the inner tubes, in the central channels of the cells and in the horizontal holes; and another variant having six fuel elements per lattice cell and with a fuel-free central zone 20 cm. in diameter forming a thermal column. The effect of water on the multiplication of the system was also studied, making use of the central channels of the lattice cells, the horizontal channels, and the internal channels of the tubular fuel elements. The table below summarises the data obtained. Details of the reactor have been published in the *British Journal of Applied Physics* (Supplement No. 5) and in the *Journal of Nuclear Energy*, April, 1957, page 520 (translated from *Atomnaya Energiya*), from which the foregoing table has been taken.

Type of reactor	Core radius (cm.)	Thickness of reflector (cm.)	Critical mass of uranium 235 (kg.)	
			Observed	Calculated (multi-method) group
With side reflector; no water	36·5	15·5	6·66	7 ± 1·4
No reflectors; no water	52	—	11·73	12 ± 1·6
Ring-shaped reactor; no water ..	42	20*	12·66	
With water in the fuel elements ..	26·2	25·8	3·42	

* The diameter of the central column containing the unloaded channels.

THUD

What is described as a new type of fuel potentially suitable for nuclear power reactors has been developed at the Argonne National Laboratory and discussed in a paper presented before the annual meeting of the American Ceramic Society at Dallas, Texas. The paper was titled: "Thoria-Urania Bodies and Irradiation Studies," and was presented by C. L. Hoenig R. J. Kittel, J. H. Handwerk, and C. R. Breden. For the first time, Argonne is using ceramic pellets of urania-thoria (UO_2 and ThO_2) fuel constituents to produce heat for electricity from a nuclear reactor. The development work was done at the Laboratory's main site at Lemont, Illinois. The pellets are now being used in a Borax series experimental reactor at Argonne's branch at the National Reactor Testing Station site near Idaho Falls, Idaho.

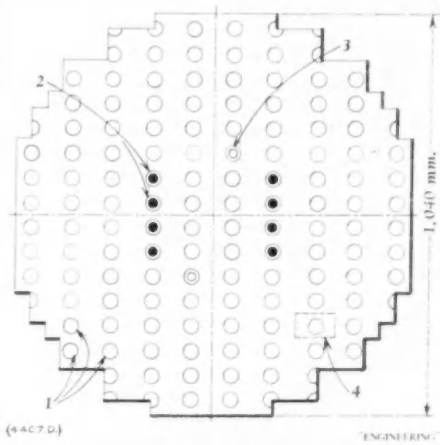


Fig. 1 Sectional plan of zero-energy beryllium-moderated testing reactor operated by the U.S.S.R. Academy of Sciences.

1. Vertical channels
2. Shut-off rods
3. Control rods
4. Lattice cell (shown enlarged in Fig. 2)

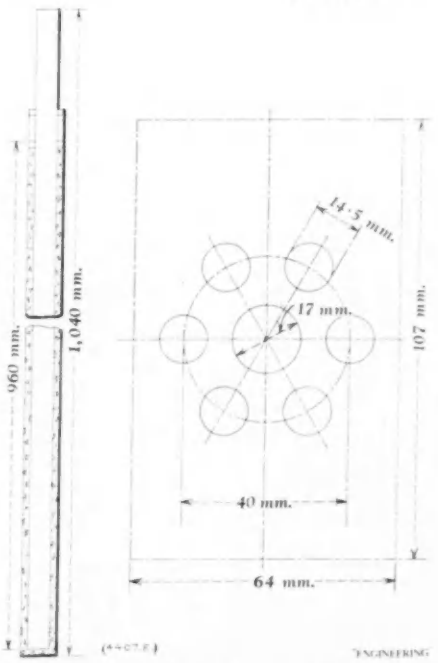


Fig. 2 Group of vertical channels in the centre of each elementary lattice cell in the Soviet beryllium-moderated reactor.

The core is composed of oxides of thorium and uranium. Both thorium oxide and uranium oxide have been used in ceramics for many years, but it is believed that the use of thorium and uranium oxides as nuclear fuels has not been tried before. One of the major reasons for the use of ceramics as fuel elements in a reactor is that they do not, like metallic fuel elements, grow and become distorted under intense irradiation. Under some conditions metallic fuel elements have been known to double in length. Crystal studies of uranium show marked changes in size and structure of the crystal under irradiation. The rolling of uranium metal tends to unify the crystals in a single direction. When a majority of the crystals lie in one direction the changes due to irradiation are enormously increased in that direction. Since ceramic crystals lie in all directions, the effect of irradiation on a ceramic nuclear fuel element is much less than on a metallic fuel element.

The ceramic specimens prepared were tested both with and without an outside protective metal covering. Aluminium nickel alloy, stainless steel and zircaloy-2 coverings were used on some specimens. Some of each kind of covered and uncovered ceramic elements were put in water or in sodium-potassium (NaK) liquid metal and irradiated. The various fuel elements showed good resistance to corrosion in either water or sodium-potassium. (Corrosion resistance is an important factor in any material put inside a nuclear reactor.) The results of the tests indicated that a ceramic core consisting of a mixture of uranium oxide and thorium oxide pellets, when sintered (fused) together and assembled in an aluminium high nickel covering, would be suitable for use in a reactor. The reactor for which the ceramic fuel was designed is BORAX-4, operated by the Argonne National Laboratory at its Idaho station. The BORAX-4 ceramic core, now in operation, was designed to test, among other things, the operation of a boiling-water reactor under more extreme heat-transfer conditions than earlier BORAX cores. Initial tests have shown that the ceramic elements can operate satisfactorily at quite high levels of power output per unit volume of core.

Some of the major potential advantages of ceramic fuels for reactors may be summarised as follows: (1) ceramics can withstand high temperatures; (2) ceramics are highly resistant to corrosion in water; and (3) ceramic fuel elements grow comparatively little under irradiation.

Fuel Rod Assemblies

Atomic Energy of Canada Limited have proposed a method of arranging fuel elements for reactors in which the cooling (and moderating) medium is heavy water. In all heavy-water cooled reactors previously constructed the fuel-rod assemblies have been composed of a cylindrical rod of fuel, normally uranium, encased in a tightly adhering sheath of suitable metal, usually aluminium, and usually an outer tube spaced from the sheath to leave a passageway through which the coolant is passed under pressure. In the formation of such assemblies one of the principal problems is the deformation to be expected in uranium metal under irradiation. Hitherto this problem had been dealt with by the use of a cylindrical form for the fuel rod so that the sheath would, even upon deformation, tend to adhere tightly to it, the tightness of the sheath being considered important to assure effective heat transfer. In addition, the fuel rod has generally been made up of short slugs rather than in one long piece. In a high-power pile the factor which governs the neutron flux obtainable is the maximum permissible temperature for the fuel. The disadvantage of the earlier arrangement is that it results in the minimum cooling surface per unit of volume of fuel, with the consequence that the neutron flux obtainable is severely limited by the maximum temperature which the fuel in the rods may be allowed to reach.

It has now been found that the cooling surface

per unit volume of the fuel, and hence the neutron flux obtainable, may be greatly increased without excessive deformation or local heating due to inadequate heat transfer from the fuel through the sheath. The fuel is formed in thin strips, usually flat, which are enclosed in a tightly fitting thin pliable sheath of any of the normal sheathing metals (aluminium, zirconium, zirconium-tin alloy or thin stainless steel). A number of these sheathed strips are arranged in a tube of circular cross-section in spaced parallel face-to-face relationship, each sheathed strip being sufficiently wide to make contact with the tube along both its longitudinal edges. Cross-sections of possible arrangements are shown in Fig. 4. Projections on the tube (*a*) or on the canning (*b* and *c*) assist in preventing bending of the fuel strips during irradiation and in maintaining the correct spacing. Water passing through the tube serves to remove heat generated in the fuel. A suitable thickness for the sheaths is 0·04 in. where the strip is between 0·15 and 0·18 in. thick. Coolant can be circulated under the usual pressure of 60 to 70 lb. per sq. in. and this pressure helps in keeping the sheaths in place on the fuel surface, so avoiding local over-heating. It has been found possible by this method to obtain about seven times as high a neutron flux as is achieved with conventional fuel assembly containing the same volume of fuel.

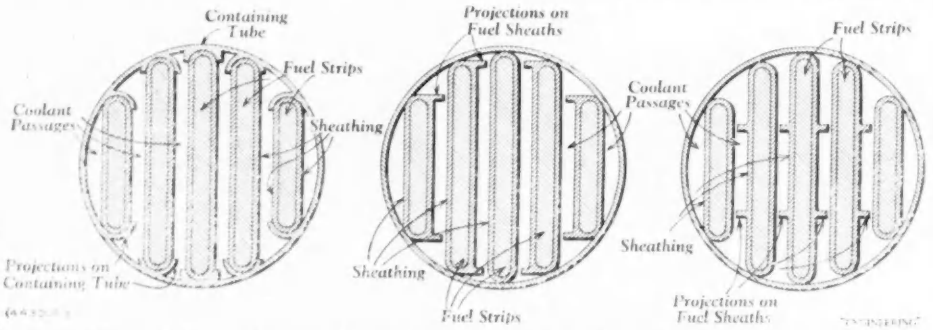


Fig. 3 To permit increased neutron fluxes without overheating a form of reactor fuel element has been proposed in which sheathed fuel strips are supported in tubes through which passes the heavy water coolant-moderator.

Flux Flattening

Although the principle of flux flattening in a reactor is already familiar, and is probably incorporated in the nuclear power stations being built for the Central Electricity Authority, it is interesting to note that an American patent on the subject has been issued as recently as December, 1956, though application may of course have been made considerably earlier. There are various methods of achieving a flattened flux, including the insertion of neutron-absorbing material differentially throughout the reactor core. The United States patent describes another approach, and is summarised as follows. The patent relates to a method of building a reactor that has a reactivity or K factor substantially uniform across the core. In the past, the area having the highest K factor has been the centre, with the result that the fuel in this area not only burns out more rapidly but also first reaches the maximum permissible temperature during operation, thus limiting the power level of the entire pile. The method proposed places the more fissile material (that is, with highest enrichment) on the periphery of the core, thus tending to equalise the K factor and neutron density over the core. It is claimed that the method results in a higher permissible operational power level and longer core life. (U.S. Patent No. 2,774,730: Gale J. Young.)

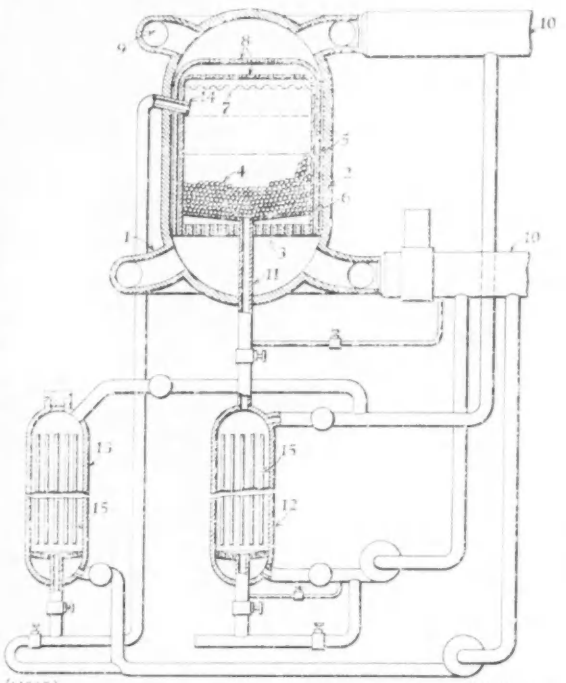


Fig. 4 Arrangement of pebble bed reactor. A fluid coolant and moderator passes upward through the bed, lifting and distributing it in such a way that conditions for a chain reaction are created.

1. Fluid inlet conduits
2. Pressure vessel
3. Perforated partitions
4. Pellet bed
5. Shielding member
6. Core container
7. Screen
8. Perforations in shield and container
9. Fluid outlet conduits
10. Primary coolant circuit
11. Pellet transporting tube
12. Used pellet container
13. Fresh pellet container
14. Pellet feed tube
15. Neutron absorbers to prevent chain reaction occurring in containers

Pebble Bed Reactor

A reactor has been described which has a core container with a perforated bottom adapted to support a bed of movable, solid fuel pellets. A fluid, which acts as both coolant and moderator, is directed upwards through the bed and used to force the pellets upwards into such a position that a chain reaction is set up and maintained. This type of reactor can be made to shut-down automatically should the pumping power fail, since the pellets will then collapse into a bed where the ratio of moderator to fuel is low and non-critical. Similarly, the reactor may be non-critical for excess coolant flow and excess bed expansion. Fig. 4 shows one form of the reactor. (British Patent No. 756,014: Westinghouse Electric International Company.)

Unloading Reactors

A method has been proposed for unloading a reactor containing uranium metal as the fissile material. Steam and hydrogen are passed in contact with the uranium metal to oxidise it to uranium oxide, which is then dissolved in place with nitric acid and the solution removed from the reactor. This method is said to dispense with the need for complicated and expensive fuel charging and discharging apparatus. (U.S. Patent No. 2,778,792: L. Szilard.)

Breeder Reactor

In a thermal breeder reactor with a high conversion ratio, the conversion of fertile to fissile material can lead to fluctuations in the reproduction factor. In addition, the operation of the reactor may be strongly influenced by fluctuations in the proportions of the moderator and fissile materials, particularly if the fissile material is dissolved or suspended in a liquid moderator. In the process described, the design of the reactor and initial fuel-moderator fluid are so selected that the susceptibility of the reactivity to fluctuations in the proportions of moderator and fuel is minimal. During operation, the reactor is then kept critical and a high conversion ratio maintained by gradually varying the proportion between the quantities of moderator and fuel material, and between the proportions of fissile and fertile material in the fuel. (British Patent No. 755,598: Stichting voor Fundamenteel Onderzoek der Materie.)

Circulation of Fluid Fuels

The pumping of highly radioactive fluids presents one of a most difficult problem. Accord-

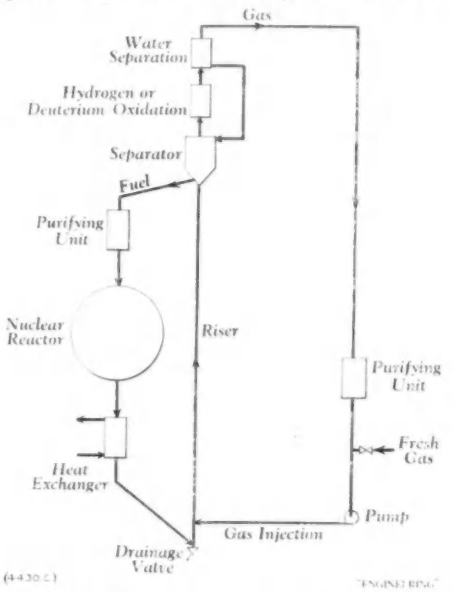


Fig. 5 Arrangement of reactor system requiring circulation of fluid fuel.

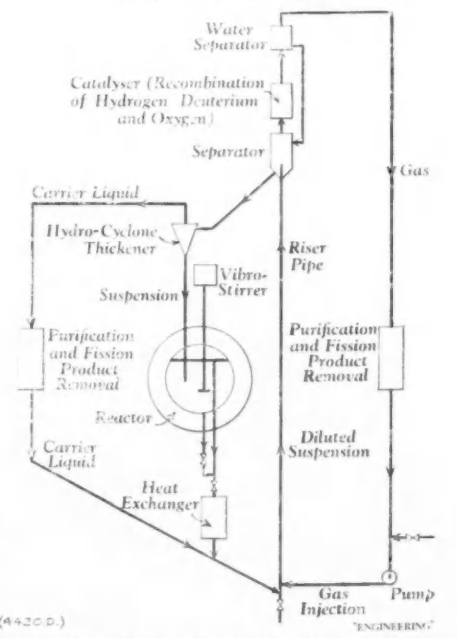


Fig. 6 Arrangement of reactor system employing a fuel in the form of a fluid-borne suspension.

ing to one invention, it can be avoided by making the fuel flow through the reactor and heat exchanger under the influence of gravity, and subsequently carrying the fluid to a level above the reactor with the aid of a vertical riser, into which gas is injected at the lower end. At the highest point of the circuit, shown in Fig. 5, the injected gas is separated from the liquid which is then allowed to flow back into the reactor. An additional advantage is that the liquid is " washed " with gas every cycle, so that fission products are partly removed. If heavy or light water is used as the fuel carrier or solvent, any gases formed by decomposition under neutron irradiation in the reactor are also removed by the injected gas, and the formation of explosive mixtures is prevented. Oxygen, helium, carbon monoxide or carbon dioxide are suitable as injection gas. (British Patent No. 755,495: Stichting voor Fundamenteel Onderzoek der Materie.)

Circulation of Fuel Suspensions

Fuel suspensions, such as uranium oxide in water, usually possess such a high viscosity at the concentrations desired within the reactor that they cannot easily be pumped. In addition, at these concentrations the fission products cannot easily be removed. According to a proposed method, these drawbacks can be eliminated by diluting the suspension outside the reactor and circulating it in its diluted state. The additional amount of carrier liquid is then separated from the diluted suspension before the suspension is re-supplied to the reactor. The separated carrier liquid may be at least partly freed of dissolved fission products and subsequently re-used. Fig. 6 shows a suitable scheme for a homogeneous reactor adapted to carry out this process. (British Patent No. 757,015: Stichting voor Fundamenteel Onderzoek der Materie.)

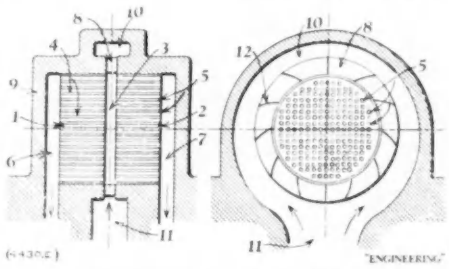


Fig. 7 Reactor cooling system designed to give centripetal flow so that cooling is most effective at the centre of reacting mass.

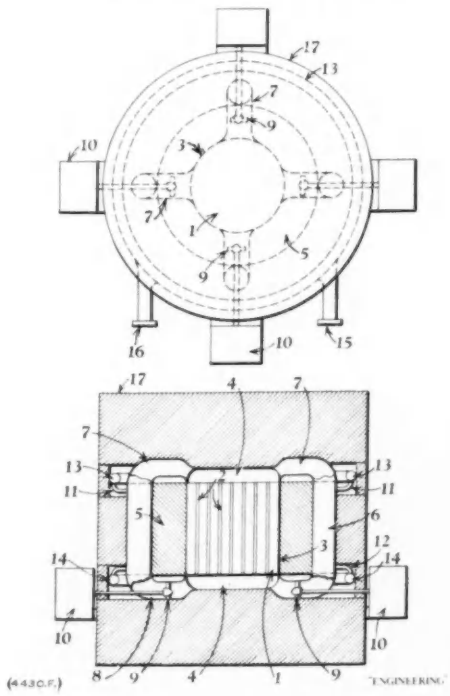


Fig. 8 (left) Cooling system for liquid-metal fuelled reactor using an intermediate liquid-metal heat exchanger. (Key given in text.)

Fig. 9 (right) Designed for educational and training purposes, the AGN201 reactor made by Aerojet-General Nucleonics can be used to demonstrate both steady state and kinetic behaviour of reactor systems.

Cooling of Liquid-Metal Fuel Reactors

If a liquid-metal reactor fuel is circulated directly to an external heat exchanger to heat water for steam raising, a large heat exchanger is required and there is an excessively large hold-up of fissile material in the exchanger compared with that in the reactor. A proposal designed to overcome this difficulty involves the use of an intermediate liquid-metal coolant circuit. The good heat transfer properties of the secondary liquid-metal coolant permit the use of a much smaller primary heat exchanger with consequent lowering of the hold-up of fissile material. In addition, the intermediate circuit provides a buffer against radioactive contamination of the steam. (British Patent No. 763,231: S. G. Bauer and C. D. Boadle, U.K.A.E.A.)

Fig. 8 is a plan view and a vertical cross-section of a thermal neutron reactor. The cylindrical core or moderator structure (1) is a mass of beryllia 148 cm. long and 148 cm. diameter pierced by a multiplicity of bores (2) having a total cross-section of 1,240 sq. cm. The core is encased in an austenitic stainless-steel drum (3) the domed ends (4) of which constitute headers for the bores (2). Around the core (1) is a partial reflector (5) made of graphite, beryllia, or water and outside this are four equally spaced heat exchangers (6) having direct radial primary flow and return connections, (7) and (8) respectively, to the headers (4). Impellers (9) driven by electric motors (10) are arranged in the return connections (8) and give a flow rate of 248 litres per second. Secondary flow and return connections (11 and 12) to the heat exchangers are taken from ring mains (13 and 14) furnished with an inlet and an outlet branch (15) and (16) respectively. The core, heat exchangers, ring mains and their associated connections are embedded in a dense concrete shield (17). The primary circuit, including the bores (2) in the core (1), is filled with a 1·05 per cent. solution of uranium 235 in 6 tons of molten lead, the weight of the uranium contact being 20 kg. giving a fissile atomic ratio of 3,000 for a core having a mass of 6,400 kg. The secondary circuit also contains liquid metal (molten sodium) so that a highly efficient liquid-metal to liquid-metal heat exchange takes place in the heat exchangers (6) and this secondary circuit is connected to a further heat exchange means (not shown). The reactor described is estimated to provide 100 MW heat at a sodium outlet temperature of 600 deg. C. With a recirculated steam type of steam generator this should provide about 40 kg. of steam per second at a pressure of 150 kg. per sq. cm. and a temperature of 500 deg. C.

Centripetal Reactor Cooling System

In an ideal cooling system for a mass in which an exothermic reaction takes place, particularly a nuclear chain reaction, the cold source would be placed at the centre of the mass. This ideal may be approached by distributing coolant channels in the mass with a feed collector which is itself fed through its periphery, so that the speed of the fluid from its entry into the collector to its entry into the channels is centripetal. Thus minimum speed of the fluid is obtained in the centre of the collector and, as a result, the maximum static pressure and maximum unitary rate of flow for the central channels.

In Fig. 7 below the reacting mass (1 and 2) is shown to be divided into two parts by a vertical slot (3) of constant width. Opening into this slot are the inlets of a certain number of horizontal channels (4 and 5) uniformly distributed in the masses (1 and 2), the outlets of which are connected to two vertical collectors (6 and 7). The slot (3) communicates at its periphery, through an annular passage (8) formed in the casing (9) with a volute (10) connected to the conduit (11), which conducts the cooling fluid. This fluid is led back into the volute (10) under a suitable total pressure by means of a blower, not illustrated. The annular passage (8) is provided with guide vanes (12) leading the fluid which penetrates into the slot through the periphery of the slot so that the speed of entry of the fluid into the slot is centripetal. (Brit. Pat. Spec. 755,291: Société Rateau.)

Training Reactor

The fourth licence for the operation of an AGN-201 100 MW reactor (Atomic Review, March 1) was issued to Aerojet-General Nucleonics of San Ramon on March 29. Seventeen further operating licence applications are pending. The U.S.A.E.C. has also issued an authorisation for the transfer of an AGN-201 from Aerojet-General Nucleonics to the U.S. Naval Postgraduate School at Monterey, California.

Applications for similar transfer authorisations have been made by Oklahoma Agricultural and Mechanical College, Texas Agricultural and Mechanical College, the University of Akron, and the U.S. Naval Hospital, Bethesda. The use of small adaptable reactors for training purposes is already becoming widespread and the nuclear reactor, sometimes regarded as necessarily bulky and immobile, is becoming available in more portable forms. A view of the Aerojet-General Nucleonics AGN-201 reactor, which was described in Atomic Review on March 1, appears in Fig. 9.

Atomic Energy in China

It has been reported that uranium and thorium are being mined on a small scale in China and that a 7MW heavy-water moderated reactor is due for completion there this year.

A VERSATILE 10 TON CRANE

The mobile road crane, which is illustrated below and was recently demonstrated at the Letchworth works of K and L Steelfounders and Engineers, Limited, is the first of the well-known Jones series to reach a capacity of 10 tons. Power both for road travel and for all the crane motions is obtained from a single 125 h.p. Diesel engine and all the controls are housed in one cabin. The crane has been designed for employment on a wide range of duties, including the handling of raw and finished products, maintenance, breakdown and constructional work and tracklaying. The scope of its operations may be increased by replacing the conventional hook with a grab or a lifting magnet. It can generally be operated "free-on-wheels," but four rigger beams with screw jacks are provided for use when heavy loads are handled.

The superstructure is mounted on a ring of ball bearings and is located on the chassis by hook rollers operating on the underside of the slewing path. The cab and the hoisting, derricking and slewing mechanisms are mounted on the chassis with only the derrick drum, A-frame and balance weight on the revolving superstructure.

Power for hoisting is transmitted from the take-off through bevel and reduction gearing, the drum being driven through an internally expanding clutch. There is an hydraulically-released automatic brake and the empty hook is lowered by a roller chain drive. The hoisting speeds are 100 ft. per min. on a single fall of rope, 50 ft. per min. on two falls and 33 ft. per min. on three falls. Speed control is either by a pedal or by a self-locking hand lever.

The slewing drive is also transmitted from the power take-off through gearing, the direction of rotation being determined by clutches. The crane can be slewed through a full circle in 24 seconds, the speed being again controlled by a pedal; and the superstructure can be locked in any position. Automatic braking is provided. Derricking, too, is effected through gearing and a chain drive which, in turn, is coupled to spur gearing. This gearing freely rotates on the centre column of the superstructure and is geared to the derrick drum through a self-sustaining worm and wheel. The derrick can be moved from maximum to minimum radius in 30 sec.

The crane can be equipped with either 30 ft., 45 ft. or 60 ft. cantilever jibs, or with strut jibs of the same lengths or of 75 ft. Self-dumping grabs with capacities up to 45 cub. ft. can be substituted for the hook as can a 7½ kW lifting magnet. Power for both is obtained from the main engine or alternatively in the case of the magnet from a self-contained unit.

All the controls are concentrated in a single cabin, which contains two driving positions. One of these is equipped with clutch, brake and speed control pedals, and hand-brake and gearbox levers, as well as with a power-assisted steering wheel for road operation. The other contains the controls for the various crane motions as well as a duplicate steering wheel and clutch, brake and accelerator pedals.

New 10 ton Jones mobile crane which is being manufactured by K and L Steelfounders.

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IMPERIAL COLLEGE

New Buildings and Jubilee Dinner

The jubilee celebrations of the granting of the Charter to the Imperial College very happily coincided with the opening by the Queen Mother of the new Roderic Hill building which will house the departments of aeronautics and chemical engineering. Imperial College has been chosen for expansion under the Ministry of Education plan and reconstruction is even now in progress. Not least is the provision of residential accommodation, aided by generous gifts from both Government and industry—a part of college life that has been sadly restricted hitherto.

It is interesting to record, as the Rector, Dr. R. P. Linstead, did at the celebration dinner at the Mansion House, that the purchase of the original site was made on the recommendation of the Prince Consort. Over 50 years later, when King Edward VII laid the foundation stone of the Royal School of Mines, he said, "As time goes on, I feel more and more convinced that the prosperity, even the very safety and existence of our country, depend on the quality of the scientific and technical training of those who are to guide and control our industries"—words that have a very modern ring about them.

Looking to the future, Dr. Linstead said there was a duty to experiment in education. He mentioned in particular both chemical engineering (which was first taught at the college in 1912) and aeronautics. Now had come a chair in Nuclear Power. Advanced post-graduate courses had been increased and transfer courses included to enable students to switch from arts to science and engineering. He hoped, however, to keep clearly in sight the main objective: to produce a well-educated man and not merely a good specialist.

The Roderic Hill building is a concrete-cased steel-frame structure covered on the main north front with Portland stone and green Westmorland slate. It comprises five floors, the total area of which is 72,000 sq. ft. The aeronautics department is west of the main entrance and the chemical-engineering department east of it; the latter also occupies the fifth floor which extends across the entire frontage of the building. In the chemical-engineering department there are at present 150 undergraduates and 100 post-graduate students, while 45 undergraduate students enter the College each year to study aeronautical engineering. There are also 20 post-graduate students of aeronautics.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Annual General Meeting. Central London Branch. White Hall Hotel, Bloomsbury-square, W.C.1. Mon., June 10, 6.30 p.m.
Annual General Meeting. South West London Branch. Prince of Wales Hotel, Hartfield-road, Wimbledon, S.W.19. Thurs., June 13, 7.15 p.m.

BIRMINGHAM
Annual General Meeting. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham 2. Wed., June 12, 6.30 p.m.

BRADFORD
Open Meeting. Bradford Branch. Midland Hotel, Bradford. Wed., June 12, 7.30 p.m.

BRISTOL
Annual General Meeting. Bristol and West of England Branch. Grand Hotel, Bristol. Fri., June 14, 7.45 p.m.

CREWE
Annual General Meeting. Stoke and Crewe Branch. Royal Hotel, Crewe. Fri., June 14, 7.30 p.m.

SOUTHSEA
Annual General Meeting. Portsmouth Branch. Royal Beach Hotel, Southsea. Thurs., June 13, 7.15 p.m.

Building Centre

LONDON
Films on industrial lighting and catering equipment, exhibited by the British Electrical Development Association. Wed., June 12, 12.45 p.m.
Film: "Timber Decay in Buildings," exhibited by Richardson and Starling, Ltd. Wed., June 19, 12.45 p.m.

Chemical Engineering Group

LONDON
"Granulation," by W. C. Peck. Society of Chemical Industry, 14 Belgrave-square, S.W.1. Tues., June 11, 5.30 p.m.

Combustion Engineering Association

LONDON
"Coal: Some Forecasts," by R. J. Moffat. London Region. St. Ermin's Hotel, Caxton-street, Westminster, S.W.1. Wed., June 12, 10.30 a.m.

CARDIFF
"The Reduction of Smoke and the Efficient Control of Combustion by Instrumentation," by W. R. L. Kent, at 10.30 a.m. "The Effect of Coal Characteristics on the Operation of Mechanical Stokers," by D. C. Gunn, at 2.30 p.m. Welsh Region. Park Hotel and Whitehall Rooms, Cardiff. Wed., June 19.

Engineers' Guild

EDINBURGH
Luncheon Meeting. Speaker: Emlyn Jones, chief road engineer, Scottish Home Department. Scottish Liberal Club, 109 Princes-street, Edinburgh. Mon., June 10, 12.30 for 12.45 p.m.

Incorporated Plant Engineers

CHESTER
"New Developments in Chemical Engineering Materials," by E. Warde. Merseyside and North Wales Branch. Stafford Hotel, City-road, Chester. Thurs., June 20, 7.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Centenary Celebrations, Tues., June 25, to Thurs., June 27. Presidential Address by Sir Harold E. Yarrow, Bt.; "A Short Biography of the First President, Professor W. J. Macquorn Rankine," by Professor J. Small; and "Nuclear Power for Ship Propulsion," by Dr. S. L. Smith and Dr. J. E. Richards, at 10 a.m. Various works visits in the afternoon. Banquet, in St. Andrew's Halls, Granville-street, Glasgow, at 7 p.m. Tues., June 25.
All-day excursion to the Firth of Clyde, Wed., June 26.
All-day works visits and excursions. Reception by the Lord Provost of Glasgow, in the City Chambers, George-square, Glasgow, at 7.30 p.m. Thurs., June 27.

Institution of Mining and Metallurgy

LONDON
"Mechanisms of Collector Adsorption and Dynamic Attachment of Particles to Air Bubbles as Derived from Surface-Chemical Studies," by J. Leja; "Flotation of Soluble Salts," by J. Rogers; and "The Assessment of Flotation Results," by J. C. Nixon and D. N. Moir. Geological Society's apartments, Burlington House, Piccadilly, W.1. Thurs., June 20, 5 p.m.*

Royal Meteorological Society

LONDON
"Airflow Over an Isolated Hill," by R. S. Scorer; "Waves in the Lee of an Isolated Hill," by R. S. Scorer and M. Wilkinson; "Airflow Over Mountains: the Lee-Wave Amplitude," by G. A. Corby and C. E. Wallington. Wed., June 19, 5 p.m.*

Royal Society

LONDON
"The Mechanical Behaviour of Single Crystals of Metals, in Particular, Copper," by Dr. E. N. da C. Andrade and D. A. Aboav; and "Dislocations and Stacking Faults in Stainless Steel," by M. J. Whelan, P. B. Hirsch, R. W. Horne and W. Bollmann. Thurs., June 13, 4.30 p.m.*

Royal Society of Health

LONDON
"The Effects of Radiation on the Individual," by Dr. F. G. Spear. Wed., June 12, 2.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.

In Parliament

MAKING KNOWN RUSSIA'S WORK IN SCIENCE

A brief discussion took place in the House of Commons last week on the need for more English translations of Russian scientific periodicals. The matter was raised by Mr. Ray Mawby (Conservative), who asked for information about the progress being made by the Department of Scientific and Industrial Research in regard to such translations and the provision of a lending library service on them. He desired to know when the lending service would commence and whether there were likely to be any political difficulties about obtaining these periodicals. Would the D.S.I.R., he asked, be prepared to translate Russian scientific papers on request?

Speaking on behalf of Lord Home, the Lord President of the Council, whose representative he is in the Commons, Mr. Harmar Nicholls, the Parliamentary Secretary to the Ministry of Works, told the House that the D.S.I.R. had placed orders for all the Russian scientific and technological books and periodicals which were available through commercial channels, and, where possible, English translations of them. The Department was also trying to obtain additional material on an exchange basis. When sufficient material had been received, a lending service would be started. The Department was continuing its small co-operative translations scheme, under which the cost of a translation of a scientific paper was shared by those interested, and was considering the provision of a more comprehensive service. The new service was now well on the way and the Government did not anticipate any difficulty in getting the exchange moving, because Russia was eager to receive British publications and, in order to get them, there would have to be a real live exchange.

Replying to a point brought forward by Mr. Emrys Hughes (Labour), as to whether any objection had been raised by the Secretary of State for Foreign Affairs on the ground that these books and documents had been written by Communists or fellow-travellers, Mr. Nicholls said that that matter had not yet come within the purview of the Foreign Office.

DEUCE'S WORK DECLINING

Speaking again on behalf of the Lord President of the Council, Mr. Nicholls said that the National Physical Laboratory's electronic digital computer DEUCE was used on the research work of the Laboratory and of other stations of the D.S.I.R. He told Mr. F. W. Farey-Jones (Conservative) that the computer provided a service for various Government departments and agencies, including the Admiralty and the Ordnance Survey. In addition, it had been used on work for the United Kingdom Atomic Energy Authority, for the universities and for private industry: the revenue earned from these bodies amounted to £17,700 in the financial year 1955-56, and to £9,500 in the year 1956-57.

Mr. Nicholls assured the House that the Government did indeed appreciate the need to see that machines of this type were fully used. He felt that the reason why the Laboratory's service in this respect had fallen off over the last twelve months was because some erst-while customers had purchased digital computers of their own. Such action was, of course, a compliment to DEUCE and its predecessor ACE. [A reference to the work of DEUCE is contained in our account of the recent Open Days at the N.P.L. on page 714.]

DISPERSING GERMAN HEAVY INDUSTRY

Recent developments regarding the spreading of heavy industry in German aroused a considerable amount of interest on the part of the Opposition. Mr. Elwyn Jones (Labour) asked the Foreign Secretary to state the Government's policy towards proposals made to them by the German Federal Government to waive the allied post-war de-concentration measures agreed upon in respect of Krupps. Mr. A. W. J. Lewis (Labour) wanted to know what action had been taken to implement the agreement signed in 1953 by Herr Alfred Krupp von Bohlen with the British, French and United States Governments to sell off his coal and steel interests in five years and that signed in the following year by Chancellor Adenauer with the Western Powers committing his Government to the destruction of the pre-war cartels. He also asked what recent discussions or negotiations had ensued with the British Government for the alteration or abrogation of these agreements and pressed for an assurance that it remained the policy of the British Government to maintain these agreements without amendment.

In his reply, Mr. Selwyn Lloyd said that in the convention on the "Settlement of Matters Arising Out of the War and Occupation," signed at Bonn in 1952, and amended at Paris in 1954, the Federal Government had agreed to complete the programme for the de-concentration of the German heavy industry undertaken under Allied High Commission legislation. This programme included the coal and steel undertakings of the firm of Krupp. It remained the policy of the British Government to maintain the Bonn conventions, but the Federal Government had drawn the attention of the British, French and United States Governments to difficulties which had arisen in some of the de-concentration measures.

The Federal Government had been asked for further information regarding the nature of these difficulties and the extent to which their obligations under the conventions had been discharged. When that information was received, the matter would be discussed with the other signatories to the Bonn conventions.

KRUPP PLAN

It was urged by Mr. Lewis that the House should be consulted before any irrevocable steps were taken and Mr. P. J. Noel-Baker (Labour) asked that the view that the Krupp family and the Krupp firm were very dangerous influences in German affairs should be pressed upon the Federal Government. Mr. F. J. Bellenger (Labour) inquired whether the Federal Government's undertaking was binding for all time. Was there, he asked, anything to prevent firms subject to de-concentration from coming together again? Mr. John Hynd (Labour) pointed out that the agreements related not to de-cartelisation but to the de-concentration of heavy industry and that they were now out-dated. Was it not better for Herr Krupp to invest his money in coal and steel than in atomic energy?

Mr. Selwyn Lloyd said he thought he could undertake to inform the House, but he would like to consider the other points raised. He understood that considerable assets of the Krupp firm had been sold and that the approach of the Federal Government was due to the practical difficulties encountered. Of course, the first steps to be taken must be to hold consultations with the other signatories to the Bonn conventions.

In a note published later by Mr. Selwyn Lloyd, under the title *De-concentration of the Coal, Iron and Steel Industries in Germany: Krupp Plan*, he gave some further explanation of the documents to which reference had been made in the House. It was stated in this note that the order giving effect to the Krupp plan had been signed by the United Kingdom, French and American chairmen of the Combined Steel Group. At the same time, Alfred Krupp von Bohlen had made a statutory declaration to the effect that he would not use the proceeds of the sale of the securities to re-acquire interests in the German coal or iron and steel industries. The provisions of allied legislation in Germany about de-concentration had previously been confirmed by the Federal Government in the Bonn conventions of 1952, and these provisions were retained when the conventions were revised and amended in Paris in 1954. The plan, it was stated, had originally been drawn up in March, 1953, by the Combined Steel Group of the Allied High Commission for Germany.

Bagdad Pact Nuclear Centre

The Bagdad Pact Nuclear Training Centre does not produce isotopes, but is designed to give training in some practical applications of isotopes and to undertake research work upon them. Mr. Ian Harvey, Joint Under-Secretary of State for Foreign Affairs, informed Sir James Hutchison, Bt. (Conservative) that the Centre is using isotopes purchased from the United Kingdom Atomic Energy Authority. The total contribution from the United Kingdom to the Centre for the financial year 1956-57 was £30,000.

Spinning and Weaving Machinery

Sir David Eccles, the President of the Board of Trade, told Mr. Harold Wilson (Labour) that manufacturers' deliveries of machinery to the home market for the weaving of cotton or staple fibre rayon were valued at £2·4 million in 1953; £2·8 million in 1954; £2·4 million in 1955; and at £2 million in 1956. Machinery delivered to the home market for spinning and preparatory processes, and for subsequent processes preparatory to the weaving of these substances, amounted to £5 million in 1953; £5·4 million in 1954; £6·1 million in 1955; and to £5·2 million last year.

Aero-Engines for Bombers

Replying to a request by Mr. Robert Cooke (Conservative) for information regarding aero-engines to be installed in the later versions of the Victor and Vulcan aircraft now under development, Mr. Aubrey Jones, the Minister of Supply, said that the later versions of the V-bombers being developed by A. V. Roe and Company, Limited, and by Handley Page Limited, would be known as the Vulcan Mark 2 and the Victor Mark 2. The first of these aircraft would be fitted with Bristol Olympus 6 engines, and the second would have Rolls-Royce Conway 11 engines.

National Certificates in Engineering

Replying to Mr. Austen Albu (Labour), who asked for particulars about students taking courses for national certificates in engineering, Sir Edward Boyle, Bt., the Parliamentary Secretary to the Ministry of Education, said that, in 1956, there were 15,840 entries for ordinary certificates in mechanical engineering, of whom 7,528 were successful. In the same year, there were 6,986 entries for ordinary certificates in electrical engineering, of whom 3,512 were successful. Higher certificates were granted to 3,260 candidates in mechanical engineering; to 2,153 in electrical engineering; to 425 in production engineering; and to 243 in civil engineering. Out of 27 applicants for higher certificates in chemical engineering, 24 were successful.

Consequences of Mechanisation

The Foreign Secretary was asked by Mr. Will Owen (Labour/Co-operative) to make a statement about the inquiry by certain experts, appointed by the Committee of Ministers of the Council of Europe, into questions concerning the social and cultural adjustments of individuals and their families, consequent upon the conditions arising from the introduction of mechanisation. The report, he understood, was presented at the Strasbourg meeting on March 25 and 26 last. Mr. David Ormsby-Gore, the Minister of State for Foreign Affairs, said that the experts had been convened by the Consultative Assembly's Committee on Social Questions, and that their report had not yet been submitted to the Committee of Ministers. He was sure that all Members of the House would be very interested in this matter, but the procedure at Strasbourg was sometimes confusing. The Ministers could not make a statement until they had received the experts' report. As soon as that report was received he would see whether it could be made generally available.

THE HUMAN ELEMENT

Negotiation is Best

A great debate on how wages should be determined is now going on. Several trade union leaders have expressed the view that a national wage policy is desirable (as discussed on this page last week, " National Wages Policy "). The annual conference of the National Union of Public Employees produced yet another influential supporter of the national wage policy concept. Their general secretary, Mr. Bryn Roberts, argued that the present methods of determining wages were iniquitous and badly needed overhauling. " If we had a single union in each industry, a supra-national wages advisory board similar to that recommended by the engineering court of inquiry would be both practical and desirable."

A possible reply to Mr. Roberts is contained in a speech by General Sir Brian Robertson, chairman of the British Transport Commission. Addressing the annual conference of the council of the branch secretaries of the National Union of Railwaymen, he argued that wage settlements in an industry are best determined by negotiation in the industry itself, " without recourse to any outside commission, court of inquiry, or arbitration."

Yet the trend is towards more and more centralisation in the unions and in industry alike. Those who negotiate have little contact with the people they represent. It is hard to see how this can be changed and, if it is not, how it can fail to lead to a political settlement of all wage claims. Whether or not " a national body to investigate and advise on wages and profits would be of enormous advantage to workers everywhere," as Mr. Bryn Roberts contends, is—to say the least—debatable.

Reward for Public Service

Despite all the Prime Minister may say about earnings having risen by 90 per cent. since the war and output by only 30 per cent., he cannot easily avoid having to put up the salaries of Ministers of the Crown and of those who serve on the boards of nationalised industries. The rewards of these men, who bear responsibilities heavier than most of the leaders in private industry, are many times less in real terms than pre-war. Last week's debate in the Lords showed that there is a great deal of concern lest the relatively low salaries offered fail to attract first class people. Lord Lucas of Chilworth, moving an amendment to the Electricity Bill, pointed out that if nationalised industries were to be run on a sound commercial basis the terms and conditions of appointment of all members " should conform to good industrial and commercial standards."

During an inflationary period it falls to public men to set an example, and for this reason the salaries of ministers and those of the leaders of nationalised industries have been held at a level far lower than the average paid to members of private boards. There is cause to believe that this has now gone too far. It is in any case doubtful if the trade unions would allow the movement of a minister's salary to affect their thinking. Voluntary restraint may have been a factor once throughout industry. It certainly is not so now, and for posts—even ministerial ones—the market rate has to be paid for the able and the successful.

On Behalf of Older Workers

With the ageing of the population in this country and the likelihood of growing public controversy about the national pensions scheme, it is important to study as much relevant material from other countries as possible. In the United States, the U.S. Department of Labor and the Bureau of Labor Statistics have issued a brochure called *Older Workers Under Collective Bargaining* (reprinted by the United States Information Service in London).

A study of 1,687 major agreements and some others covering about 7·5 million workers has been made to find out the status of older workers in the framework of management-labour negotiations. These agreements were in operation during 1956 and 1957. In most cases the specific problems of older workers (itself a difficult term to define) has not been written into formal wage agreements. The most effective practices developed by unions have been the rules of seniority and protection against arbitrary discharge. In some cases seniority has been modified to bring in an element of efficiency. On the whole, major wage agreements do not offer older workers specific protection against loss of employment. Only a few agreements contain a provision that some older workers must be hired or that there will be no discrimination against the older man when he seeks a job. On the other hand there is a certain amount of protection on the job for the older worker since his seniority accumulates privileges. There is indeed a marked difference between the older worker who has attained seniority within the organisation and the older man who applies for a job and it seems likely from the report that the trend of negotiations is going to accentuate that difference and thus make mobility of older men increasingly sluggish.

Jerking the Strings

There is ill-feeling concerning the conditions accepted by the Confederation of Shipbuilding and Engineering Workers in return for the wage increase in the engineering industries. The foundry workers and the boilermakers both expressed their disapproval at their annual conferences. Mr. Gardner, general secretary of the former, told of a plan to circumvent the 12 months standstill in wage claims. This is very much as expected—namely, a claim for a reduction in the basic working week from 44 to 40 hours without less pay; consolidation of piece-workers' supplements in their basic rates and an increase from two to three weeks' annual paid holidays.

Mr. E. J. Hill, general secretary of the boilermakers', was even more outspoken. He gave his terms for a settlement of the outstanding wage disputes in the shipbuilding industry: namely, 11*s.* a week without any strings. For the unions' members in the engineering industries he suggested that they should not be too dismayed about the strings, for they could not stop the unions giving notice of strike action after exhausting the usual procedure. The stage would appear to be set for more trouble, but the level of the unions' strike funds may well be low enough to cause the leaders to be more cautious in their actions than in their speeches.

Training Electrical Engineers

Specific cases are always refreshing when there is a surfeit of generalisations: one such instance has been the description of the Scottish Electrical Training Scheme Limited, described by Mr. J. E. C. McCandlish at the education conference organised recently in London by the British Electrical and Allied Manufacturers' Association.

The address can be only briefly summarised here. The Scottish electrical engineering industry consists mainly of specialised firms and therefore loses (in its own opinion) too many undergraduates yearly to English concerns with broader training facilities and the Scots' problem is that these men tend to stay in the south where they have been trained. To produce professional engineers for Scotland, a limited company was formed (limited by guarantee). The founding organisations have been the two Scottish electricity boards and five electrical engineering companies. The governing directors come from the founding members and there are seven academic advisory directors. The plan is to catch men young and get them to go right through a graduate course to final employment with one of the member companies. Trainees are bound only by a gentleman's agreement to stay for one year with the company concerned after their post-graduate training.

Membership for companies involves three things. They must be able to provide training facilities up to the standard of corporate membership of the Institution. They must take one man per year over a series of years—not just one man at a time. Finally they must adhere to the financial arrangements of SETS, as it has come to be called.

Steadying Labour Turnover

The difference between full and overfull employment has been the subject of interesting comment by Mr. L. J. Cadbury, chairman of Cadbury Brothers. For the first time since the war staffing their Bournville factory became easier last year. The recession in the motor industry raised unemployment only slightly from 0·4 per cent. at the beginning of 1956 to 0·9 per cent. at the end, but at one time reached 2·5 per cent. The effect on Cadbury's was considerable.

Labour turnover was reduced considerably—a thousand fewer men left the factory than in 1955. Absenteeism fell sharply. The standard of applicants was higher and efficiency improved because the proportion of untrained recruits to the total work force of 11,500 was much less.

The effect of the high labour turnover most companies have experienced under conditions of " overfull employment " is almost impossible to measure accurately. Most employers are agreed that it is considerable, and many union leaders would concur. That a small rise in unemployment should have so considerable an effect on a company who are traditionally very good employers is something worthy of the most careful study.

The Candidate Animal

An article " Jobs for the Boys " in the latest issue of the *Journal* of the University of Liverpool Engineering Society deals in bantering vein with the question of interviewing technologists and graduates for jobs. Nevertheless behind its faintly cynical and lighthearted approach it says a number of useful things with commendable brevity on the subject.

It is a fact to-day that managements are faced with an awkward problem in interviewing young men either to show them the openings available or to make a formal assessment of their suitability for a post. In a seller's market there is a nice line to be drawn between duly impressing the visitor and over-selling. The article provides a short list of " don'ts " for managements. There is a similar list for the graduate.

Perhaps it could be summed up briefly by saying on the employers side, don't play formulas, interviewing techniques and salesmanship to death. On the other side the phrase might be to avoid any appearance of superciliousness. To both sides the plea is really to use common sense. It is a simple piece of advice that cannot be repeated too often over the next few years when so much is going to be said, both good and bad, about training the engineer and getting him into the right job.